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Responses of Ornamental Plants and Woody Trees to Salinity

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SUMMARY

Plants can also be affected by the toxicity of some elements in saline water, especially chloride, sodium and boron. Some of the early signs that salinity in water or soil is affecting plants are:

- Salt injury includes leaves scorching or mottling, leaves shedding and twig dieback.
- Salt injury may include fragmentation of cuticles and injury to cell membrane increases solutes leakage.
- Salinity results in poor germination and establishment:
- Salinity inhibits vegetative growth of non-halophytes, with reduction of shoot growth more than root growth.
- Plant anatomy is often altered by salinity such as:

  1. Leaves become thicker and more succulent.
  2. The great leaf thickness may reflect more layers of mesophyll cells, larger cells or both.
  3. Salinity stimulated suberization of the root.

- Increases number of salt-tolerant plants, such as some woody trees *(Leucaena luecocephala, Melia azedarach, Dalbergia sissoo, Casuarina gluaca and Khaya senegalensis)*
- In non-halophytes, salt-induced inhibition of plant growth is accompanied by metabolic dysfunction, including decreased photosynthetic rate and changes in enzymatic activity.
- In halophytes, physiological processes may be stimulated or not altered by salt concentrations that are inhibitory in non-halophytes.
- Salinity decreases carbohydrates or growth hormones, thereby inhibiting growth.
- High salt concentrations inhibit enzymes by impeding the balance of forces controlling the protein structure.
- Salinity affects negatively the nutritional balance of plants.
- Ornamental plants and woody trees vary in their degree of salinity tolerance from sensitive to very tolerant.
- Salt tolerance varies widely among species and genotypes. Plants adapted to salinity by tolerating or avoiding salt. In some plants, salt tolerance is achieved by osmotic adjustment. This may involve absorption of ions from the soil followed by isolation of ions in vacuoles.
- Salt avoidance mechanism includes salt exclusion and dilution of salt in the plant.

GENERAL

All plants are subjected to a multitude of stresses throughout their life cycle. Depending on the species of the plant and the source of the stress, the plant responds in different ways. The major environmental factor that currently reduces plant productivity is salinity [1]. There are global constraints on fresh water supplies and this had led to a surge of interest in reusing water [2]. Salt stress can be a major challenge to plants. It limits agriculture all over the world. As more lands become salinized by poor irrigation practices, the impact of salinity is becoming more important [3]. This is creating the need for salt tolerant plants.

Egypt is a predominantly arid country and the scattered rain showers in the north can hardly support any agricultural crops. Agriculture thus depends mainly on irrigation from the River Nile. The needed increase in food production to support the acceleration in population growth (2.7%) compels the country to use all sources of water (i.e. drainage water, groundwater and treated sewage water) for the expansion of irrigated agriculture.

This paper reviews aim at recognizing and highlighting the problem of salinity.

Effect of salinity on ornamental plants and woody trees:
1) Injury: Salinity adversely affects plant by inducing injury, inhibiting growth, altering in plants morphology and anatomy, often being a prelude to tree mortality [4].

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Injury is more severe when salts absorbed from the soil are augmented by salts deposited on leaves. General symptoms include stunted growth and reduced yields. All parts of the plant, including leaves, stems, roots and fruits, may be reduced in size.The signs and symptoms displayed by displayed by deciduous and broad-leaved trees and shrubs include leaf necrosis (death), marginal leaf of needle burn, leaf drop and eventual plant death.Entire leaves can be affected and drop prematurely. Buds may fail to open or grow and branches may die. Sometimes deciduous trees may exhibit early fall color and leaf drop. Salt damage on deciduous trees and shrubs usually becomes evident in late summer following the growing season,or during periods of hot, dry weather(summer drought).On conifers (firs, junipers, pines, spruces), damage appears as brown needle tips. The brown discoloration progresses toward the base of the needles as salt exposure increases. Salt damage on evergreen trees and shrubs [both conifers and broadleaf (hollies, photinia, southern magnolia)] usually first appears in late winter to early spring and becomes more extensive during the growing season. In extreme situations, trees and shrubs will die due to soil Sali damage [5].

Injury is induced not only by the osmotic effect of salts but also by specific toxic effects resulting from the accumulation of Cl^- and Na^+. Evidence for non-osmotic effect of salinity on injury to plants can be summarized as follows:

- Individual salts have different critical concentration for inducing injury.
- Certain organic solutes increase the critical salts concentrations for injury.
- Injurious effects of salts are antagonized by Ca^{+2}.

Both Cl-and Na^+ may cause injury, but symptoms of Cl-injury usually appear first. Chloride injury develops marginal chlorosis of leaves of broad-leaved trees, followed by extensive scorching of leaf blades. Sodium accumulation in leaves is typified by leaf mottling and necrotic patches [5] or by tip burn or both salts injury to leaves often is followed by leaf shedding and twig die back. As salinity was increased, Na replaced K to a large extent in all tissues. Chloride was the major balancing anion in all tissues. Salinity injures cell membranes and solute leakage [6]. The effect of NaCl on membrane leakage is counteracted by Ca^{+2}. Application of NaCl to foliage of *Thuja accidentalis* and *Picea glauca* induced fragmented cuticles, disrupted stomata, collapsed cell walls, coarsely granulated cytoplasm, disintegrated chloroplasts and nucleic and disorganized phloem [7].

2) Seed germination: To both nonhalophytes and halophytes, salinity reduces the total number of seeds germinating and postpones initiation of germination processes; however, within each group the responses are variable and related to the species specific. Salinity influences seed germination primarily by lowering the osmotic potential of the soil solution sufficiently to retard water absorption by seeds, but also by toxicity to the embryo [8]. Seeds of many halophytes accumulate less than 10% of the ionic content present in shoots, indicating that they process a mechanism for preventing excess ion accumulation in the embryo. Wamgwattana *et al.*[9]tested the effect of NaCl on germination of seeds of some trees and the results showed that *Centrosema pubescens* was the most tolerant to NaCl (0.125, 0.250, 0.500, 1.00 and 2.00%) followed by *Leucaena leucocephala* and *Sesbania rostrata*. Similarly, Sherbeeni [10] tested the effect of soil salinity levels of NaCl, $CaCl_2$ and NaCl: $CaCl_2$ (1:1) on germination of seeds of some trees. Results indicated that salinity treatments decreased seed germination percentage. The germination percentage of *Leucaena leucocephala, Melia azedarach* and *Dalbergia sissoo* were progressively related with the concentration of salts. The major effects of salinity on seed germination retardation could be attributed to decreasing rate and total amount of water absorbed and increasing the entry of certain ions into the seed, which are toxic in high concentration

3) Vegetative growth: Salinity reduces vegetative and reproductive growth of non-halophytes. Combined flooding and salinity typically decrease growth and survival more than stress alone [11].

Maynard *et al.* [12] studied the growth of spruce (*Picea glauca*) under saline water (EC of 0, 0.5, 1.0, 1.7 and 3.1 c) conditions, the results indicated that the growth decreased to reach 50% in the 0.5 dS m^{-1} treatment compared with the control. EL-Settawy and EL-Gamal [13] studied the effect of salinity at 0, 1, 5 and 10 mg NaCl/g soil on *Casuarina glauca* seedlings and found that plant height, stem diameter, total dry matter were decreased by increasing salinity stress. Genhua [14] watered the following trees and shrubs which were used for this subject: Black cherry (*Prunus serotina*), Green ash (*Fraxinus pennsylvanica*), Lacebark elm (*Ulmus parvifolia*), Russian olive (*Elaegnus angustifolia*), Sand cherry (*Prinis besseyi*), Sand plum (*Prunus angustifolia*) and Desert willow (*Chilopsis linearis*) with saline irrigation at 0.8 (Tap water), 2 and 4 dS m^{-1} electrical conductivity The photos in Fig. 1 showed that based on caliper growth and visual quality, lacebark elm was most salt tolerant among the tested species.

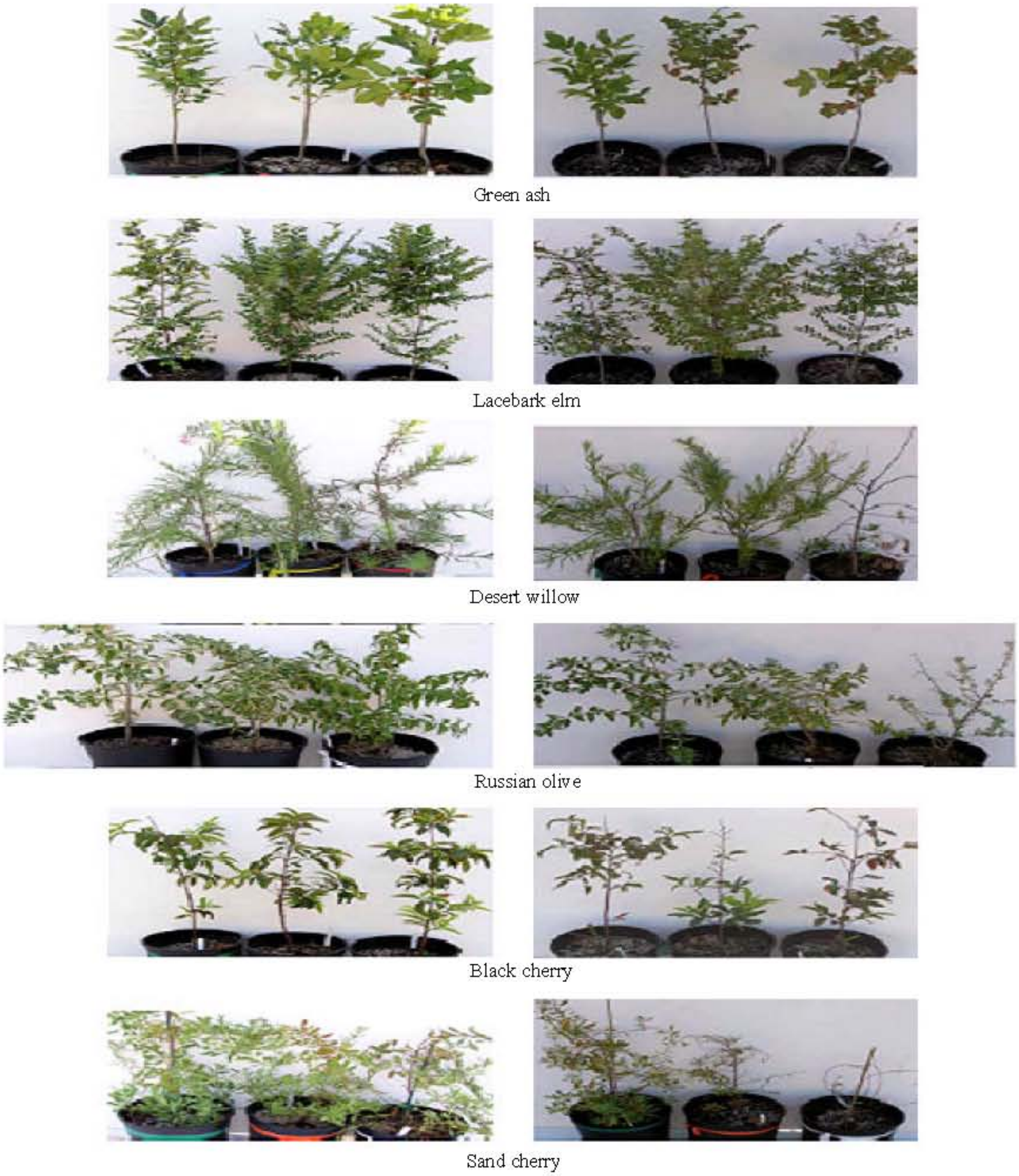

Fig. 1: Photos on the left side: One month after the initiation of saline solution irrigation; on the right side: 3 months after the saline solution irrigation. Plant species from top to the bottom: Green ash, lacebark elm, desert willow, Russian olive, black cherry and sand cherry. Source: Genhua N. [14]

It did not have any foliage injury due to salt and its caliper increased by 30 to 40 percent in three months. Russian olive had leaf injury and defoliation in some plants when irrigated at 4 dS m^{-1} and caliper of most plants increased by 20 to 30 percent. Similar results to Russian olive were observed on Desert willow. Sand plum, Sand cherry and Black cherry had severe defoliation in elevated salinity treatments and did grow significantly. Green ash plants also had leaf injury but was better than the above three species.

4) Morphological and anatomical changes: Salinity often alters the morphology and anatomy of woody plants. Leaves of *Quercus lobata* and *Q.agrifolia* that grow on saline soil often are thicker and more succulent than those of trees growing on salt-free soils. The epidermal cell walls and cuticles of leaves of salinized plants also are thicker. Salinity often promotes suberization of hypodermis and endodermis in roots than is found in non-salinized roots. The walls of root cells of salinized plants often are unevenly thickened and convoluted [15].

In salinized *Gossypium hirsutum* plants, the leaves were thicker because the number of cell layers increased and the mesophyll cell were larger, whereas in citrus, increase in the size of spongy mesophyll cells, rather than an increase in cell layers, accounted for thicker leaves [16].

The large cells of leaves of salinized plants result from increased cell wall extensibility together with higher turger pressures. Salinity not only inhibits the rate of cambial growth but also influences the anatomy of cambial derivatives. Following exposure of *Aesculus hippocastanum* trees to salinity, the number of xylem vessels increases and their size decreases [17].

5) Physiological responses: Salt-induced slowing of plant growth is accomplished by a variety of metabolic dysfunctions in nonhalophytes, including inhibition of enzymatic activity, photosynthesis, absorption of minerals, protein and nucleic metabolism and respiration. Addition of NaCl to mitochondria isolated from leaves of a nonhalophyte (*Pisum sativum*) and a halophyte (*Suaeda Maritima*) reduced the rate of O_2 uptake by both species. Salinity affects synthesis of carbohydrates as well as transport of photosynthetic products and their utilization in production of new tissues. In many halophytes, important physiological processes are stimulated or not altered by salt concentrations that inhibit these processes in nonhalophytes.

Gas exchange: Salinity reduces the rate of photosynthesis of both halophytes and nonhalophytes [18]. Although both stomatal and nonstomatal factors have been implicated in the reduction of photosynthesis following flooding with saline water, most of the reduction in photosynthetic rates in the result of nonstomatal effects. In the long term, total photosynthesis is reduced as a result of inhibition of leaf formation and expansion as well as early leaf abscission [4].

Following irrigation of *Fraxinus pennsylvanica* seedlings with low concentrations of salt solution, the leaves progressively dehydrated, causing partial stomatal closure and decreased CO_2 absorption. However, after plants were flooded with high concentrations of salt solution, photosynthetic inhibition was attributed to ion toxicity, membrane disruption and complete stomatal closure [19]. For the first few days after flooding of *Ficus carica* plants with salt solution, stomatal conductance was reduced but the rate of photosynthesis was not altered; however, longer-term salinity treatment greatly inhibited the rate of photosynthesis by non stomatal effects [20].

Mineral nutrition: Salinity often upsets the nutritional balance of plants by one or more mechanisms including osmotic effects of salts, competitive interactions among ions in the substrate and effects on membrane selectivity. As root elongation slows, the amount of ions reaching the roots by diffusion decreases. High concentrations of Cl^- reduce NO_3^- uptake by plants and high concentrations of NO_3^- inhibit phosphate uptake. Salinity decreases uptake of K, Ca and Mg in phylloclades of *Casuarina equistifolia* [21].

Epron and Toussaint [22] watered *Quercus robur* with a nutrient solution containing either 50 or 250 mM NaCl and found that Na^+ content strongly increased in all plant tissues with increasing NaCl concentration. Prevention of Na translocation in shoot moderately stresses oak (*Quercus robur)* probably requires an extra energy, may be provided by an increase in maintenance respiration.

Than *et al.* [23] studied change in Na^+ and K^+ content under stress in seedlings of 10 trees species *Pinus koraiensis, P. sylvestris Var. mongolica, Picea karaiensis, Larix kaenpferi, Larix olgensis, Abeis holophylla, Frxinus mansharica, Tilia amurensis, Ulmus pumila and Betula platyphylla.* They found that significant differences in Na^+ and K^+ contents among trees species; Na^+/K^+ increased with the increase in salinity of the medium, but the increase was lower in tolerant species than in intolerant ones. Adding $CaCl_2$ to the medium was effective for decreasing Na^+/K^+ ratio.

Sherbeeni [10] found that using NaCl, $CaCl_2$ and their mixture (1:1 by weight) in concentrations; 0, 1000, 2000, 3000 and 4000 ppm. The three used salts at all concentrations decreased N, P and K contents in different plant parts of *leucaena lecocephala* as compared to control. Meanwhile, using saline water at different concentrations increased Na, Ca and Cl contents in the plant parts as compared to control with the exception of Ca content.

Hormones: The balance between root and shoot hormones changes considerably under saline conditions. Salinity reduces cytokinin production in the roots and its transport to the shoots. The supply of cytokinin to the leaves increases transpiration and synthesis of some proteins Therefore, a reduction in the supply of root hormones to the leaves may result in reduced transpiration in growth rate. On the other hand, water reduces transpiration [24].

Mechanisms of growth depression: The mechanisms by which salinity inhibits plant growth have elucidated precise characterization, although there has been considerable success in describing their physiological manifestations. Over the years emphasis has been placed on three aspects of the physiological effects of salinity on plant growth: 1) turgor regulates stomatal conductance and cell expansion, thereby affecting growth of plants in soils of low water potential, 2) plant growth is limited by a lowered rate of photosynthesis and 3) excessive uptake of salts affects production of a specific metabolite that directly inhibits growth. The mechanisms of short-and long-term inhibition of shoot growth by salinity may vary [7].

Munns [25] concluded that the absorbed salts do not directly control growth by influencing turgor, photosynthesis, or activity of a specific enzyme. Meanwhile showing the complexity of salinity effects, she developed a model that incorporates a two-phased plant growth response to salinity; growth is first reduced by a decrease in soil water potential (a water stress effect) and later a specific effect appears as salt injury in the old leaves, which die because of a rapid increase of salt in cell walls or cytoplasm when vacuoles can no longer sequester incoming salts. The proposes of the accumulation of salt in the old leaves accelerated their death and loss of these leaves decreased the supply of carbohydrates or growth hormones to meristematic regions, thereby inhibiting growth.

Adaptations to salinity and how to alleviate the harmful effects of salinity: Plant growth retardants are widely used in modern agriculture. Compounds like chlorolmequate chloride, mepiquate chloride, ethephon and latter uniconazole can be applied successively to solve growth problems alleviate the harmful effects of salinity. In this concern, many Investigators reported that exogenous application of some growth retardants reduced the toxicity of salinity and sometimes enhanced the growth ([26] used ABA on Carthamus tinctorius). It is well known that physiological processes in plants pass through many metabolic pathways and lead to metabolic products. Exogenous application of growth retardants on plants grown under sa lt stress may reduce physiological effects disorders.In this respect, the increase in chlorophyll content of uniconazole treated plants could be referred to hormonal effects as it has been noted earlier that cytokinins stimulate chlorophyll synthesis. Cytokinins also accelerate chloroplast differentiation and stimulate chlorophyll production [27]. Plants treated with uniconazole and grown under saline condition tended to have a darker green color than untreated,this darker colour is desirable to consumers and makes the plants more saleable, these darker foliage can be attributed to greater chlorophyll concentrations and carotenoids in the leaves [28, 29]. It may be mentioned that carotenoids provide photosynthetic systems with a method of photoprotection. Singlet $1/2O_2$ is an extremely powerful oxidant, which is very harmful to the plant, carotenoids prevent the formation of singlet oxygen by quenching the triplet states of the chlorophyll molecules as they arise [30].Concerning the effects of growth retardants on the amounts of total carbohydrates as well as total soluble-sugars of the plants grown under saline condition, the results recorded showed significant increases in these criteria [28, 29]. It could be concluded that the accumulation of such these compounds (e.g. glycerol) might be attributed to osmotic adjustment (osmoregulations) in a trial to maintain its turgidity and to overcome the increased resistance to water uptake in roots then helped the plants to tolerate the salinity stress.

The accumulation of new proteins in vegetative tissue of plants subjected to salinity and treated with growth retardants may be one of the important protective characteristic mechanisms which result in avoidance of injuries effects of salt stress [28]. Recently, Bekheta [29] stated that,application of paclobutrazole on plants grown in newly reclaimed regions induced appearance of some new protein bands. These new bands of protein may play an important physiological role to alleviate the harmful effects of environmental stress on wheat plants.

There is a wide spread phenomenon that subjecting plants to environmental stress e.g. salt stress or water stress induced proline accumulation in the cells of these plants. Proline is believed to protect plant tissues against stress by acting as nitrogen-storage compound, osmosolute and hydrophobic protectant for enzymes and cellular structures [31]. Many investigators reported that proline content is affected to different extent by combined action of growth retardants and salinity [28].

Plants subjected to stress undergo increased exposure to activated form of oxygen and accumulation of free radicals associated with damage to membranes and build up of lipid peroxides. Plant cell normally are protected against such effects by a complex antioxidant system. This system includes three general classes; (1) lipid soluble, membrane associated antioxidants (e.g. tocopherol and B-carotene) (2) water soluble reductants (e.g. Glutathione and ascorbate) (3) enzymatic antioxidants e.g. super oxide dimutase "SOD", catalase, peroxidase and enzymes of ascorbate-glutathione cycle. In different species tissues and developmental stages tolerant to water stress, reduced membrane damage has been linked to increased enzymatic defenses agoxygen radicals, together with synthesis of free radical scavengers [32].

Carotenoids prevent the formation of singlet oxygen by quenching the triplet states of the chlorophyll molecules as they arise [30].

Bio-regulators in general and growth retardants in particular play an important role for increasing the resistance of the plants to grow under stress conditions. This resistance might be attributed to changes in the levels of endogenous hormones (e.g. ABA, cytokinins, Gas, IAA, polyamines, ethylene.....etc.). In this concern, elevated ABA levels in the leaves are important for rapid osmotic adjustment via stomatal closure [33]. They also favor the accumulation of amino acids in general and praline in particular and improve the adaptation to salinity.

Kinetin can partially counteract the adverse effects of salinity [34]. There are also some reports on the reduction or even prevention of salt induced growth depression by cytokinins (CYT), Gibberellic Acid (GA) or Indole Aceitic Acid (IAA). Cytokinins are variety of compound that stimulate water uptake, increase cell division, promote organ development and lead to generation and proliferation of shoots and branches [35].

It is clear that the combined treatments between uniconazole and salinity on plants decreased the levels of IAA and GA_3 while increased the levels of ABA and cytokinins. These increments may be due to interference of uniconazole in gibberellin biosynthesis through inhibiting the oxidation of ent-kaurene to entakaurenoic acid: this will result in furnishing more substance for the biosynthesis of cytokinins and abscisic acid [28].

To ameliorate or to alleviate the harmful effects of salinity on the yield and its components, seed pretreatment or plant treated with growth retardants. In this concern, Bekheta, [28-29] showed that application of growth retardants uniconazole or paclobutrazole on *Vicia faba* and wheat plants respectively led to increases in all the yield parameters compared to corresponding salinity control. He also postulated that these increments could be a reflection of the effects of uniconazole or paclobutrazole on growth and development, it might be due to: 1) marked increases in the number of bean branches and wheat tillers 2) Increases in the endogenous contents of ABA, CYT, Proline, Protein, photosynthetic products as well as carotenoide.

Gorham [36] stated that woody plants may adapt to salinity by variously tolerating or avoiding salt, or both. Most highly salt-tolerant halophytes withstand high tissue salt concentrations largely through osmotic adjustment. The absorbed salts typically are sequestered in vacuoles, hence reducing the salt concentration to which the cytoplasm and chloroplasts are exposed [15]. In some plants, osmotic adjustment results from synthesis in the cytoplasm of compatible organic solutes (including proline, glycine, betaine and other amino acids in addition to sugars). The cytoplasm often contains high concentrations of organic compounds that balance the high salt concentrations in the vacuoles but do not inhibit the functioning of enzymes and membranes.

Although most salt-tolerant halophytes and non-halophytes respond to saline stress by osmotic adjustment, there are exceptions including some halophytes (e.g. *Suaeda maritima*) which grow faster as salinity increases and some plants that can adapt to salinity if exposed to low concentrations of salinity [37].

Kozlowski and Pallardy [4] mentioned that salt avoidance mechanisms may involve passive salt exclusion, active salt dilution of salt as it enters a plant. Application of the growth inhibitor paclobutrazol promoted avoidance of salt stress in *Prunus persica* by reducing uptake accumulation of Na^+ and Cl^- in plant tissues [38].

Some halophytes possess mechanisms for both salt tolerance and avoidance. For example, *Avicennia marina* has three mechanisms of salt resistance; 1) salt exclusion by low permeability of roots to salts, 2) salt tolerance and 3) release of salt through glands. Many plants adapt to salinity by more than one mechanism and these tolerance mechanisms interact. Thus, adaptation to salinity is determined by the integrated effects of several mechanisms [36].

Table 1: Average values of agronomic characters as affected by salinity and Eptam herbicide. Combined analysis for two seasons

Salinity conc.	Eptam herbicide L/fed.	Plant height (cm)	Straw yield/plant	Head diameter (cm)	Head weight (gm)	Weight of seeds/head	Seed index (wt. of 100 seeds)
0	-	110	135.7	6	34	8	2.1
1000	-	127	150.6	8	43.3	11.3	2.7
2000	-	117	142.2	6.6	34	10.2	2.4
X		118	142.8	6.86	37.1	9.83	2.4
0	3	128.6	147.2	7.6	44.3	12.5	2.8
1000	3	143.3	159.1	9.3	51.3	13.9	3.4
2000	3	133	150.7	8.6	44.4	12.8	2.9
X		134.9	152.3	8.5	46.66	13.06	3.03
L.S.D. at 5% level		N.S	7.967	0.395	2.131	1.329	N.S

Source: El Quesni and El Gayar [39]

Table 2: Stem length, stem diameter and root length of *Khaya senegalensis* as affected by salinity and ascorbic acid

Characters	Stem length (cm) Ascorbic (ppm) (B)				Stem diameter (mm) Ascorbic acid (ppm) (B)				Root length (cm) Ascorbic acid (ppm) (B)			
salinity (ppm) (A)	0	200	400	Mean	0	200	400	Mean	0	200	400	Mean
Control	42.90	50.67	54.25	49.27	12.10	14.70	15.50	14.10	24.77	35.00	37.00	32.26
1000	42.30	45.00	49.97	45.76	11.70	14.00	14.30	13.30	23.40	33.50	34.67	30.52
2000	37.90	39.83	48.33	42.02	11.00	13.00	13.30	12.4	22.73	30.83	31.73	28.43
3000	33.27	35.60	44.57	37.81	10.00	12.00	12.70	11.60	17.47	24.90	28.10	23.49
Mean	39.09	42.78	49.28		11.20	13.40	14.00		22.09	31.06	32.28	
LSD 0.5%												
A				3.053				0.260				2.637
B				2.493				0.212				2.153
(A)*(B)				4.317				0.367				3.726

NB Control: Tap water Source: Abd El-Azziz *et al.* [40]

Table 3: Nitrogen, phosphorous, potassium and sodium contents (%) of *Khaya senegalensis* as affected by salinity and ascorbic acid

	N Ascorbic acid ppm				P Ascorbic acid ppm				K Ascorbic acid ppm				Na Ascorbic acid ppm			
Salinity ppm	0	200	400	Mean	0	200	400	Mean	0	200	400	Mean	0	200	400	Mean
Control	0.84	0.91	0.97	0.91	0.41	0.67	1.12	0.73	3.95	4.17	4.48	4.23	0.10	0.06	0.03	0.06
1000	0.73	0.85	0.91	0.83	0.39	0.56	0.88	0.60	3.35	3.51	3.75	3.54	0.18	0.12	0.05	0.12
2000	0.66	0.78	0.84	0.76	0.38	0.50	0.83	0.57	2.92	3.19	3.33	3.15	0.22	0.15	0.07	0.15
3000	0.62	0.66	0.80	0.69	0.28	0.38	0.62	0.43	2.29	2.71	2.89	2.63	0.28	0.18	0.11	0.09
Mean	0.71	0.80	0.88		0.37	0.53	0.86		3.13	3.40	3.64		0.20	0.13	0.07	

NB Control:Tap water Source: Abd El-Azziz *et al.* [40]

Table 4: Effect of sulfur amendment on chlorophyll a and b and carotenoids (mg/ g. F.W) of *Dalbergia sissoo* under different levels of salinity

	Chlorophyll (a) sulfur (g)				Chlorophyll (b) sulfur (g)				Carotenoids sulfur (g)			
Salinity ppm	0	5	10	Mean	0	5	10	Mean	0	5	10	Mean
control	2.17	2.23	2.33	2.24	0.65	0.71	0.79	0.72	0.92	0.97	1.15	1.01
1000	1.93	2.01	2.17	2.04	0.56	0.66	0.73	0.65	0.87	0.93	0.98	0.93
2000	1.81	1.85	2.03	1.90	0.53	0.62	0.65	0.60	0.82	0.91	0.93	0.89
3000	1.62	1.68	1.76	1.75	0.48	0.55	0.61	0.55	0.63	0.69	0.81	0.71
4000	1.30	1.34	1.58	1.41	0.43	0.48	0.53	0.48	0.55	0.59	0.76	0.63
Mean	1.77	1.83	1.97		0.53	0.60	0.66		0.76	0.82	0.93	

NB control: Tap water, Source: Mazher *et al.* [41]

Table 5: Effect of sulfur amendment on proline, phenols and indoles contents of *Dalbergia sissoo* under different levels of salinity

	Proline (μm g^{-1}) sulfur (g)				Phenols (mg g^{-1} F.W) sulfur (g)				Indoles (mg g^{-1} F.W) sulfur (g)			
Salinity ppm	0	5	10	Mean	0	5	10	Mean	0	5	10	Mean
control	3.9	3.5	2.9	3.43	13.4	12.1	10.7	12.1	1.83	1.67	1.58	1.69
1000	4.7	4.1	3.5	4.10	15.2	13.3	11.0	13.2	1.91	1.84	1.70	1.82
2000	5.5	4.8	4.1	4.80	16.7	15.1	13.1	15.0	1.99	1.88	1.74	1.87
3000	6.7	5.6	5.0	5.77	19.1	17.4	15.1	17.2	2.07	1.95	1.83	1.95
4000	8.2	7.2	5.8	7.07	21.4	18.3	16.4	18.7	2.14	2.01	1.94	2.03
Mean	5.8	5.04	4.23		17.2	15.3	13.3		1.99	1.87	1.76	

NB control: Tap water, Source: Mazher *et al.* [41]

Table 6: A list of ornamental plants representing their sensitivity and tolerance degree to salinity

Very sensitive (threshold less than 2 dS m^{-1})	
Dahlia spp.	Dahlia
Gardenia spp.	Gardenia
Lilium spp.	Lily
Photinia×fraseri 'Robusta'	Photinia
Rhododendron spp.	Azalea, rhododendron
Rosa spp.	Rose
Sensitive (threshold less than 4 dS m^{-1})	
Aster spp.	Aster
Gladiolus spp.	Gladiolus
Magnolia grandiflora	Magnolia
Mathiola incana	Stock
Nandina domestica	Heavenly bamboo
Strelitzia reginae	Bird of paradise flower
Zinnia elegans	Zinnia
Moderately tolerant (threshold less than 6 dS m^{-1})	
Agapanthus spp.	African lily
Chrysanthemum spp.	Chrysanthemum
Dianthus caryophyllus	Carnation
Tolerant (threshold less than 8 dS m^{-1})	
Metrosideros excelsa	NewZealand Christmas tree
Rosmarinus officinalis	Rosemary
Very tolerant (threshold less than 13 dS m^{-1})	
Araucaria heterophylla	Norfolk Island pine
Banksia spp.	Banksia
Casuarina distyla	She-oak
Source: Handreck and Black (1999)	

Ornamental plants and woody trees may adapt to salinity by variously tolerating or avoiding salt, or both. In this context, different researches were carried out to overcome hazards of salinity.

El Quesni and El Gayar [39] investigate the effect of salinity (control,1000 and2000 ppm) and Eptam (EPTC) herbicide and their interaction on some agronomic characters of sunflower. Significant increases were recorded in straw yield per plant,head diameter,head weight and weight of seeds per head by increasing salinity to 2000 ppm.The above mentioned characters were significantly by applying eptam herbicide alone or accompanied with saline water.The highest values of yield components were obtained by eptam treatment under 1000 ppm salinity { Table (1)}

Abd El-Azziz *et al*. [40] tested the effect of foliar spraying with ascorbic acid (0, 200 and 400 ppm) and three levels of salinity (1000, 2000 and 3000 ppm) and tap water serves as control on *Khaya senegalensis* (Table 2 and 3). Salinity treatments have a depressing effect on various growth parameters (i.e. stem length, stem diameter and root length). The same tendency was observed regarding the percent of N, P and K. On the contrary, all previous growth parameters and chemical constituents, except the percentage of Na, tended to increase by increasing the concentration of ascorbic acid up to 400 ppm as compared to the untreated ones.

Mazher *et al.* [41] on *Dalbergia sissoo* tree indicted that (Table 4 and 5) the use of saline irrigation water decreased the contents of Chlorophyll a, b and carotenoids while a pronounced increase was noticed for proline, phenols and indoles contents. On the other hand, all those above mentioned gave the opposite results with sulphur application. The interactive effects between sulphur and salinity levels showed a markedly decrease in proline, phenols and indoles contents, while chlorophyll a, b and carotenoids contents increased.

As concerning ornamental plants, Handreck and Black [42] show the relative tolerance (approximate 25% growth reduction) of ornamental plants to salinity (Table 6) growing conditions in media.

REFERENCES

1. Serrano, R., 1999. A glimpse of the mechanism of ion homeostasis during salt stress. Journal of Experimental Botany., 50: 1023-1036.
2. Shannon, M.C. and C.M. Grieve, 1999. Tolerance of vegetable crops to salinity. Scienta Horticulturae. 78: 5-38.
3. Winicov, I., 1998. New molecular approaches to improving salt tolerance in crop plants. Annals of Botany., 82: 703-710.
4. Kozlowski, T.T. and S.G. Pallardy, 1997. Physiology of woody plants. 2nd Edn. Academic Press, San Diego. Calif.,U.S.A.
5. Volkmar, K.M., Y. Hu and H. Steppun, 1998. Physiological responses of plants to salinity:A Review. Can. J. Plant Sci., 78: 19-27.
6. Hautala, E.L., A. Wulff and J. Oksanen, 1992. Effects of de-icing salt on visible symptoms, element concentrations and membrane damage in first year needles of roadside Scots pine (*Pinus sylvestris*). Ann. Bot. Fenn., 29: 179-185.
7. Kozlowski, T.T., 1997. Responses of woody plants to flooding and salinity. Tree Physiology Monograph.
8. Zekri, M., 1993. Salinity and calcium effects on emergence, growth and mineral composition of seedlings of eight citrus rootstocks. J. Hort. Sci., 68: 53-62.
9. Wamgwattana, C., M, Nanakorn, S. Surawattanon and K. Kobayashi, 1998. Effect of sodium chloride on growth and root nodulation in some leguminous plants. J. Weed Sci. Snd Tech., 43: 129.

10. Sherbeeni, S.A., 2001. Effect of salinity on germination, growth and chemical constituents of some timber trees. M. Sc. Thesis Fac. Agric. Cairo. Univ.
11. Noble, C.L. and M.E. Rogers, 1994. Response of temperate forest legumes to waterlogging and salinity. In Handbook of Plant and Crop Stress. Ed. M. Pessaraki. Marcel Dekker, New York, pp: 473-496.
12. Maynard, D.G., K.I. Mallett and V.L. Myrholm, 1997. Sodium carbonate inhibits emergence and growth of greenhouse-grown white spruce. Cand. Jour. Soil. Sci., 77: 99-105.
13. EL-Settawy, A.A and A.A. El-Gamal, 2003. Effect of salinity stress on the growth of *Casuarina glauca* Sieber Ex Spreng and nodulation by endobiont frankia. Alex. J. Agric. Res., 48: 149-156.
14. Genhua, N., 2005. Impact of drought on salinity tolerance of landscape woody plants. Irrigation with reclaimed water. Texas Agric. Exp. Station, EL Paso, Texas A and M Univ. System.
15. Shannon, M.C., C.M. Grieve and L.E. Francois, 1994. Whole-Plant response to salinity. In Plant-Environment Interactions. Ed. R. E. Wilkinson. Marcel Dekker, New York, pp: 199-244.
16. Zekri, M. and L.R. Parsons, 1996. Response of split-root sour orange seedlings to NaCl and polyethylene glycol stresses. J. Exp. Bot., 41: 35-40.
17. Eckstein, D., W. Liese and N. Parameswaran, 1996. On the structural changes in wood and bark of a salt-damaged horse chestnut tree. Holzforschung 30:173-178 (C. f. Tree Physiology Monograph No.1) [http://www.heronpublishing.com/tp/monograph/kozlowski.pdf].
18. Micklebart, M.V. and T.E. Marler, 1996. Root zone sodium chloride influences photosynthesis, water relations and mineral content of sapadilla foliage Hortscience, 31: 230-233.
19. Pezeshki, S.R. and J.L. Chambers, 1990. Effect of soil salinity on stomatal conductance and photosynthesis of green ash (*Fraxinus pennsylvanica*). Can. J. For. Res., 16: 569-573.
20. Golombek, S.D. and P. Lüdders, 1993. Effect of short-term salinity on leaf gas exchange of the fig (*Ficus carica* L.). Plant and Soil, 148: 21-27.
21. Dutt, S.K., A.R. Bal and A.K. Bandy Opadhay, 1991. Salinity induced chemical changes in *Casuarina equistifolia* Forst. Egypt. J. Soil Sci., 31: 57-63.
22. Epron, D.M. and P.M. Toussaint, 1999. Effect of sodium chloride salinity on growth and respiration in oak seedlings. Annals of Fores. Sci., 56: 41-47.
23. Than, Y., Q. Chan, S. Yuan, G. Liu and C. Yang, 1999. K^+ and Na^+ content change in trees under salt stress and with tree salt tolerance. J. Nothe. Forest. Univ., 27: 24-27.
24. Kuiper, D., J. Schuit and P.J.C. Kuiper, 1997. Actual cytokinin concentrations in plant tissue as an indicator for salt resistance in cereals. Plant and Soil., 123: 243-250.
25. Munns, R., 1992. Phyiological processes limiting plant growth in saline soils. Some dogmas and hypothesis. Plant Cell Environ., 16: 18-24.
26. Gadalla, M.A.A., 1996. Abscisic acid, temperature and salinity interactions on growth and some mineral elements in Cathamus plants. Plant Growth Regul., 20: 225-236.
27. Harvey, B.M.R., B.C. Lu. and R.A Fletcher, 1974. Benzyladenine accelerates chloroplast differentiation and stimulates photosynthetic enzymes activity in cucumber cotyledons. Canad. J. Bot., 52: 2581-2586.
28. Bekheta, M.A., 2000. Physiological studies on the effect of uniconazole on growth and productivity of Vicia faba plants grown under different levels of salinity Ph.D, Cairo Univ. Bot. Depart.
29. Bekheta, M.A., 2004. Combined effect of gibberellic acid and paclobutrazol on wheat plants grown in newly reclaimed lands. J.Agric.Mansoura Univ., 29: 4499-4512.
30. FyFe, P., R.J. Cogdell, C.N. Hunter and M. R.Jones, 1995. Study of the carotenoids binding pocket of photosynthetic reaction centre from the purple bacterium *Rhodobacter spharodes*. P. Mathis. (Ed), Proceeding of X^{th} International photosynthesis congress Montpellier, France 20-25 August.
31. Mansour, M.M.F., 2000. Nitrogen containing compounds and adaptation of plants to salinity stress. Biol. Plant., 43: 491-500.
32. Smirnoff, N., 1993. the role of active oxygen in the response of plants to water deficit and desiccation. New Phytol. 125: 27-58.
33. Khan, T.L., S.E. Fender, E.A. Bray and M.A. Oconnel, 1993. Characterization of expression of drought and Abscisic acid regulated tomato genes in the drought resistant species (*Lycopersicon Pennellii*) plant Physiol., 121: 211-233.
34. Katz, A., K. Dchan and C. Itai, 1978. Kinetin reversal of NaCl effects plant Physio., 62: 836-837.
35. Latham, D.S. and L.M.S. Palni, 1983. The biosynthesis and metabolism of Cytokinins. Ann. Rev. Plant Physiol., 34: 163-197.
36. Gorham, J., 1996. Mechanisms of salt tolerance of halophytes. In Halophytes and Biosaline Agriculture. Plant Physiol., 132: 678-682.

37. Casas, A.M., R.A. Bressan and P.M. Hasegawa, 1991. Cell growth and water relations of the halophyte *(Atriplex nummularia* L.) in response to NaCl. Plant Cell Rep., 10: 81-84.
38. Abou El-Khashab, A.M., A.F. El-Sammak, A.A. Elaidy, M.I. Salama and M. Reiger, 1997. Paclobutrazol reduces some negative effects of salt stress in peach. J. Amer. Soc. Hort. Sci., 122: 43-46.
39. EL-Quesni, F.E.M. and S.H. EL-Gayar, 1993. Effect of salinity and Eptam herbicide on some agronomic characters and chemical composition of sunflower. Zagazig J. Agric. Res., 20: 623-631.
40. Abd EL-Azziz, G. Nahid, Mazher, A.M. Azza. and E. El-Habba, 2006. Effect of foliar application spraying with ascorbic acid on growth and chemical constituents of *Khaya senegalensis* grown under salt condition. Amer-Euras. J. of Agric. Environ. Sci., 1: 207-214.
41. Mazher, A.M. Azza, Zaghloul, M. Sahar and A.A Yassen, 2006. Response of *Dalbegia sissoo* to sulphur application under saline condition. Am. Eur. J. Agric. Environ. Sci. 1: 215-224.
42. Handreck, K. and N. Black, 1999. Growing media for ornamental plants and turf; New South Wales University Press.