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Modern methods for counteracting salinity stress: A review

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Abstract

Salinity in soil or water resources is one of the major environmental stresses that limit plant growth and productivity. Almost 1/3 of the irrigated lands in the world is under salinity problem. Plant performance usually expressed as crop yield, plants biomass or crops quality, and may be adversely affected by salinity-induced nutritional disorders. These disorders may result from the effect of salinity on nutrient availability, competitive uptake, transport or partitioning within the plant. This paper reviews how to improve the nutritional status of the crop grown under salinity stress through traditional and new techniques.
Keywords: salinity, NaCl, Nutrient managements, Halophytes, Foliar feeding

Introduction

Salt stress is one of the most serious limiting factors for crop growth and production in the arid regions. About 23% of the world's cultivated lands is saline and 37% is sodic (Khan and Duke, 2001).

Soils can be saline due to geo-historical processes or they can be man-made. The water and salt balance, just like in oceans and seas determine the formation of salty soils, where more salt comes in than goes out. Here, the incoming water from the land brings salts that remain because there is no outlet and the evaporation water does not contain salts.

Soil salinity in agriculture soils refers to the presence of high concentration of soluble salts in the soil moisture of the root zone. These concentrations of soluble salts through their high osmotic pressures affect plant growth by restricting the uptake of water by the roots. Salinity can also affect plant growth because the high concentration of salts in the soil solution interferes with balanced absorption of essential nutritional ions by plants (Tester and Devenport, 2003).

It is well established that higher plants can withstand high salinity by either salt exclusion or salt inclusion (sykes, 1992). Salt excluders possess the ability to exclude salts from the entire plant or from certain organs. In such cases membrane selectivity favors the uptake of K^+ over Na^+, thus excluder crops are characterized by having low Na^+ and Cl^- content. Salt accumulators, on the other hand, are able to cope with the uptake of high salt concentrations through one of two strategies. The first, a common characteristic of halophytes, is through tolerating high levels of intercellular salts by resistant cell membranes. In such cases, high tissue Na^+ to K^+ ratio is evident. The second strategy is through removal of excess salt entering the plant, where root can take up salt ions but avoid their injurious effect (Badr and Shafei, 2002).

To improve crop growth and production in the salt-affected soils, the excess salts must be removed from the root zone. Methods commonly used in reclamation such soils are scraping, flushing and leaching. These methods were found to be very expensive. Recently, attention was given to use other new technologies of combating salinity, among them using halophytes. Halophytes are plants that can tolerate high salinity levels and remove the accumulated salts from the surface layer of the soil as well (Shaaban and El-Fouly, 2002). Halophytes are plants from over 80 families which evolution have developed ways to deal with large amount of salts in the water they uptake (Epstein, 1985). Some halophytes have specialized leaf cells called salt glands that excrete salt. Others have salt hairs present on the stem that excretes salt. Some plants have stomatal guard cells that are controlled by the sodium ion. These plants control their transpiration in accordance to the amount of salt present in the environment. The use of such plants to reclaim salty-affected soils has become cheaper and more practical than chemical reclamation (Ashour *et al*., 2002).

Another approach to minimize the harmful effect of salinity is the use of foliar feeding of nutrients for increasing plant salinity tolerance by alleviating Na^+ and Cl^- injury to plants (Alpaslan *et al*., 1999, El-Fouly and Salama, 1999, Schmidhalter *et al*., 1999, El-Fouly *et al*., 2002 and 2003).

Classification of salt-affected soil

Saline and sodic soils can significantly reduce the value and productivity of affected land. Soil salinity and related problems generally occur in arid or semiarid climates where rainfall is insufficient to leach soluble salt from the soil or where surface or internal soil drainage is restricted. Salinity problems can also occur on irrigated land, particularly when using brackish or saline water for irrigation. Ions most commonly associated with soil salinity include the anios: chloride (Cl^-), sulfate ($SO^=_4$), carbonate ($CO^=_3$) bicarbonate (HCO_3^-) and sometimes nitrate (NO^-_3) and the cations sodium (Na^+), calcium (Ca^{++}), magnesium (Mg^{++}) and sometimes potassium (K^{++}).

Salt-affected soils are divided into three groups depending on the amounts and kind of salt present. The classification depends on total soluble salts (measured by electrical conductivity (E.C.), soil pH and exchangeable sodium percentage) Table (1) summarizes the categories.

Table (1): Classification of salt- affected soil

Classification	Electrical conductivity (mmhos/cm)	Soil pH	Exchangeable sodium (%)
Saline	> 4.0	< 8.5	< 15
Sodic	< 4.0	> 8.5	> 15
Saline-sodic	> 4.0	< 8.5	> 15

Source: Cardon and Mortvedt, 2001 > = greater than < = less than

Plant growth as affected by salinity and plant

The soil salinity as well as irrigation with saline water depresses all growth parameters of the plants, especially the more sensitive ones.

El-Fouly et al., 2002 found that the dry weight of different plant organs of tomato was reduced in response to the increase of NaCl level in the root growth medium. However, 1000 ppm NaCl slightly decreased tomato leaves dry weight (15%), while 2000 and 3000 ppm NaCl showed dramatically depression in dry weight of all plant organs. They also found that, spraying tomato seedlings with a micronutrient compound containing 2.8% Fe +2.8% Zn + 2.8% Mn at rate of 1.5 ml/l had a positive effect on increasing the dry weight of different plant organs (Table 2). Zinc application has been found to improve growth in salt-stressed tomato plants (El-Shreif *et al*., 1990). Iron foliar application found to improve the nutritional status of maize seedling grown under salinity stress (Salama *et al*., 1996).

Awada *et al*., 1995 exposed seedlings of *Phaseolus vulgaris* to NaCl or Na_2SO_4 at concentration of 0, 15, 45 and 60 mM/l combined with either 15 or 30 of CaSO4 or $CaCl_2$. They found that increasing Na concentration decreased dry weight, number and weight of pods and number of nodules. They also reported that calcium sulfate treatments ameliorated Na-induced salinity in snap bean more than did comparable Ca Cl_2 treatment. Barley is considered a salt tolerant glycophyte crop. Javed *et al*., 2003 studied the differential response of three barley genotypes at four levels of NaCl (2.5 as control, 10, 15 and 20 dS/m) They found that salinity caused reduction in all the yield components of barley genotypes such as spike length, number of spikelets per spike, fertile tillers per plant, grain yield and 100 grain weight. The studied genotypes differed widely in their response.

To increase plant tolerance to salinity, the source of nitrogen can play an important role. Bar *et al*, 2003 found that good growth of avocado was obtained at 16 meq./l Cl^- in the presence of 16 meq./l NO_3 concentration .

Table 2: Effect of spraying with micronutrients on the dry weight of tomato plants under different level of NaCl salinity.

Treatment	Dry weight (g/pot)						
	Leaves	%	Stem	%	Root	%	Root/shoot
Control	2.50	100	1.85	100	2.12	100	0.49
1000 ppm NaCl	2.13	85	2.07	112	2.14	101	0.51
2000 ppm NaCl	1.23	49	1.15	62	1.19	56	0.50
3000 ppm NaCl	1.11	44	1.31	71	1.16	55	0.48
Control + MN	2.37	95	2.26	122	2.14	101	0.46
1000 ppm NaCl + MN	2.20	88	2.17	117	2.64	125	0.66
2000 ppm NaCl + MN	2.03	81	1.63	88	1.93	91	0.53
3000 ppm NaCl + MN	2.20	88	1.92	104	2.17	102	0.53
LSD 5%	0.83		0.50		0.48		

El-Fouly et al., 2003

In this connection, Al-Mutawa and El-Katony, 2001 studied the response of to wheat cultivars (Giza-157 and Sakha-8) grown hydroponically under greenhouse to different levels of salinity (0, 75 and 150 mM NaCl) in the nutrient solution containing either NH_4 or NO_3 as sole nitrogen source at concentration of 12 mM. They found that growth of both cultivars particularly, Sakha-8 was better under nitrate than under ammonium nutrition. Ammonium-fed plants were poorly developed with distinctly lower root:: shoot ratio and thick, short and highly branched roots compared with nitrate-fed plants (Table 3). Khalifa and Zidan, 2001 showed similar findings, where the high concentration of NH4-N reduced dry matter yield of corn.

Table (3): Dry weight (DW) of shoots and roots of cv. Giza-157 and cv. Sakha-8 of wheat under different levels of salinity for 6 days with either ammonium or nitrate as the sole nitrogen.

Nitrogen source	mM NaCl	Giza-157		Sakha-8	
		Shoot DW mg/plant	Root DW mg/plant	Shoot DW mg/plant	Root DW mg/plant
$NH4^-$	0	56.5	14.0	57.0	15.6
	75	44.8	12.6	44.0	12.0
	150	45.4	12.8	44.0	12.4
$NO3^+$	0	70.0	36.4	76.2	35.7
	75	58.6	32.9	52.2	29.0
	150	50.7	28.9	52.9	30.9

Source: Al-Mutawa and El-Katony, 2001

Crowley *et al*., 1999 suggested that maintenance of high potassium and calcium in the root zone might help to offset the effect of salinity. Navarro *et al*., 1999 with melon plants grown hydroponically investigated the interaction of P and Ca under saline conditions on vegetative biomass production, yield and fruit quality. They found that increase of Ca concentration in the nutrient solution under saline conditions improved vegetative growth and fruit yield. Parameters of fruit quality were affected by salinity (10 and 80 mM NaCl), phosphate (0.2 and 1 mM) and Ca^{+} (2 and 8 mM) nutrition. Salinity increased fruit quality by increasing firmness, total sugars and total soluble solids. High Ca treatment increased sucrose, fructose and glucose, this effect being greater under low salinity (10 mM NaCl) conditions than under high (80 mM Nacl). Schmidhalter *et al*., 1999 reported that salinity can markedly decrease leaf growth of wheat in early developmental stages. Leaf growth in these stages strongly influences tiller number which leads to marked yield losses.

In spinach beet, El-Fouly *et al*., 2004 found that NaCl-salinity treatments in irrigation water (fresh water, water contains 50 and 100 mM NaCl) had a negative effect on dry weights of both shoot and root. Foliar application of macronutrients could ameliorate such negative effect (table 4). They also found that root growth appears to be less affected by salinity than shoot as shown by the marked increase in root/shoot ratio at the highest salinity treatment (100mM NaCl).

Table (4) Effect of macronutrients foliar application under NaCl-saline water irrigation on spinach beet rowth.

Growth characteristic	Shoot DW (g/pot)			Root DW (g/pot)			Root/shoot ratio		
Treatment	NF	WF	Mean	NF	WF	Mean	NF	WF	Mean
Control	4.79	4.01	4.40	1.77	1.39	1.58	0.37	0.34	0.36
50mM NaCl	3.65	3.04	3.35	1.42	1.07	1.25	0.39	0.35	0.37
100mM NaCl	2.38	1.70	2.04	1.07	0.74	0.91	0.45	0.44	0.45
Mean	3.61	2.91		1.42	1.07		0.41	0.38	

Source: El-Fouly *et al*, 2004 NF= nutrient foliar WF = water foliar

Abou El-Nour, 2002 reported that irrigation of maize plants with mixture of 2000 ppm NaCl and 2000 ppm $CaCl_2$ decreased plant shoot and root dry weights by 24 and 21%, respectively. However, plants irrigated with saline water and sprayed with micronurrients compound contained Fe, Mn and Zn each 2.8% at rate 1.5g/l increased root dry weight by 19% as compared with control treatment. The previous treatment could decrease the depression in shoot growth from 21 to only 6%.

It is also important to note that in spite of increasing Cl ions in the nutrient medium can replace nitrate ions in their colloid-chemical function and are supposed in this way to have a positive effect on NO_3 content of plants (especially vegetable crops) to prevent excessive NO_3 concentration. In this connection, Inal et al., 1998 found that fresh and dry weights of carrot increased significantly with mixed NO_3/Cl treatment with both Cl sources (KCl and $CaCl_2$) compared to single NO3 (100/0) treatment. Growth was enhanced up to 80/20 NO3/Cl as shown in Table (5)

Flores et al., 2003 found that moderate salinity (30mM NaCl) did not reduce tomato yield when NO_3 was the only source of nitrogen. Although, Salinity and NH_4 markedly increased fruit quality, this effect was associated with a decrease in tomato yield.

Nutrient contents and plant metabolism as affected by salinity and plant nutrition

It is well known that under salt stress conditions, soils are frequently characterized by extreme ratios of Na/K, Na/Ca and Cl/NO_3. That leads to plant nutrient imbalances or deficiencies (Schmidhalter *et al*., 1999). Almost all micro- and macronutrient contents decrease in the roots and shoots with increasing NaCl concentration in the growth medium. El-Fouly *et al*., 2002 found that Na uptake markedly increased with increasing NaCl in tomato growth medium (1000-3000 ppm MaCl). Also, all micro and macronutrients uptake were negatively affected with increasing NaCl concentration. However, foliar feeding with micronutrients could partially counteract the negative effect of NaCl on nutrients uptake through improving root growth. Salama *et al*., 2004 found that high salt concentration (1000, 2000 and 5000 ppm NaCl) in the root growth medium of wheat plants was found to limit the uptake of nutrients in the different organs.

Table (5): Fresh and dry weights of carrot as affected by NO3 versus Cl nutrition

NO_3/Cl	Fresh weight		Mean	Dry weight		Mean
	KCl	$CACl_2$		KCl	$CACl_2$	
100/0	44.31	54.06	49.19 b	4.45	5.59	5.02 b
90/10	103.53	78.47	91.00 ab	11.79	8.16	9.98 ab
80/20	118.15	118.02	118.09 a	12.85	12.36	12.61 a
70/30	119.56	115.39	117.48 a	12.37	12.11	12.24 a
60/40	98.17	128.70	113.43 a	12.15	14.64	13.40 a
LSD 5%			44.22			5.14
Cl source			NS			NS
NO_3/Cl			**			**
Interaction			NS			NS

Source: Inal *et al*., 1998

Bar *et al*, 1987 stated that low nitrate concentration in the soil was followed by uptake of higher chloride quantities than those taken up when the nitrate concentration was high. This lead to conclusion that under salinity conditions it is prefer to apply nitrogen in the form of nitrate to decrease chloride toxicity (tables 6&7). Khalifa and Zidan, 2002, also found that NO_3-N was more effective in increasing total nitrogen content of plant tissues than the same concentration of NH_4-N. Combination of NO_3 and NH_4 always induced both higher yield and N content than single treatment of NH_4-N. The recovery of NO_3-N form was much higher than NH_4-N form under saline soil condition.

Achilea and Barak, 1999 mentioned that potassium nitrate, is an ideal fertilizer for a safe crop nutrition regime under saline conditions. The ratio of the two nutrients is similar to the optimal ratio found in many crops. Furthermore, considering the positive contribution of NO_3 and K against the deleterious effect of Cl and Na, respectively, KNO_3 and its derivatives should be the basis for sustainable crop nutrition for N and K.

Table 6: Effect of chloride and nitrate concentrations in the nutrient solution on chloride content (%DW) in the leaves of two avocado rootstocks.

Rootstock	NO_3 (meq/l)	Chloride concentration (meq/l)			
		2	4	8	16
Mexican	2	0.68	1.08	0.88	1.97
	8	0.56	0.41	0.70	1.51
	16	0.53	0.53	0.78	1.11
	Average	0.59	0.68	0.79	1.54
West Indian	2	0.48	1.11	0.76	1.59
	8	0.33	0.61	0.82	1.42
	16	0.33	0.37	0.78	1.02
	Average	0.38	0.70	0.79	1.45

Source: Bar et al, 1987

Table (7): Effect of chloride and nitrate concentrations in the nutrient solution on chloride content (% DW) in the root of two avocado rootstocks.

Rootstock	NO_3 (meq/l)	Chloride concentration (meq/l)			
		2	4	8	16
Mexican	2	1.00	1.05	0.80	1.58
	8	0.81	0.83	0.93	0.90
	16	0.83	0.58	0.71	0.76
	Average	0.88	0.82	0.82	1.08
West Indian	2	1.00	1.22	1.24	1.33
	8	1.03	1.07	1.30	1.57
	16	0.93	0.92	0.94	1.09
	Average	0.99	1.07	1.16	1.33

Source: Bar et al, 1987

Depression in hormone due to irrigation with saline water was noticed (Ebad *et al.*, 1992). Since, under salinity stress the content of auxins, gibberellins and cytokinins are obviously decreased.

Tester and Davenport, 2003 reported that metabolic toxicity of Na^+ is largely a result of its ability to compete with K^+ for binding sites essential for cellular function. More than 50 enzymes are activated by K^+ and Na^+ cannot substitute in its role. Thus, high levels of Na^+ or high Na^+:K^+ ratios can disrupt various enzymatic processes in the cytoplasm. More over, protein synthesis requires high concentration of K^+, owing to the K^+ requirement for binding of tRNA to ribosomes.

In pearl millet, Albassam, 2001 found that salt stress inactivated nitrate reductase activity due to decreased NO_3 uptake. Moreover, he found that high nitrate (10mM) in irrigation solution is necessary to decrease Cl- and to convert inactive nitrate reductase to an active form .

El-Leboudi *et al.*, 1997 found that increasing salinity reduced the content of free amino acids in wheat as a result of decreasing nitrate reductase activity that plays an important role in conversion of nitrate to ammonium. Grattan and Grieve, 1999 in a review paper stated that salinity dominated by Na^+ salt not only reduces Ca^{2+} availability but also reduces Ca^{2+} transport and mobility to growing regions of the plant, which affect the quality of both vegetative and reproductive organs. Also, nutrient additions have been more successful in improving the case. For example, correction of Na-induced Ca deficiencies by supplemental calcium. Qadir and Oster, 2003 reported that reclamation of sodic and saline-sodic soils is driven by providing a source of Ca^{2+} to replace excess Na^+ from the cation exchange sites. The replaced Na^+ should be leached from the root zone through excess irrigation. Nutrient additions may also reduce the incidence of injury as has been observed in the reduction of Cl^- toxicity symptoms in certain tree crop by nitrate application. They also mentioned that Cl^- uptake was reduced in cucumber when NO_3 was added to the solution but when half of NO_3 in the solution was replaced by NH_4, Cl accumulation was enhanced.

Badr and Shafei, 2002 found that salinity of irrigation water increased Na^+ and Cl^- concentration in leaves of two wheat varieties (Sakha-8 and Giza-162). While, the increase in K application could be useful to relatively overcome the adverse effect of salinity (Table 8).

Some research indicates that salinity stress may increase P requirement of a certain crops. For example, Awad *et al.*, 1990 found that when NaCl increased in the substrate from 10 to 50 to 100 mM, the P concentrations in the youngest mature tomato leaf necessary to obtain 50% yield increased from 58 to 77 to 97 mmol. /kg dry weight, respectively. On contrary, Gunes *et al.*, 1999 reported that salinity increased the P uptake of the plants, and so, plants in saline medium were found to be more sensitive to P toxicity and consequently, to Zn deficiency. Zinc application in such cases could alleviate possible Na and Cl injury in plants (Alpaslan *et al.*, 1999).

Table (8): Effect of salinity and K nutrition on shoot Na/K and shoot/root of two wheat varieties.

K_2SO_4 Level	NaCl mM	Na/K	Shoot/root	Na/K	Shoot/root
		Sakha-8		Giza-162	
1.5 g/pot	0	0.058	0.304	0.073	0.442
	50	0.218	0.652	0.284	0.802
	100	0.548	0.905	0.819	1.263
	150	1.025	1.063	1.475	1.821
3.0 g/pot	0	0.055	0.191	0.064	0.170
	50	0.173	0.375	0.305	0.589
	100	0.381	0.860	0.741	1.142
	150	0.746	1.231	1.308	1.778

Source: Badr and Shafei, 2002

Halophytes as a tool for salt control

From the fact that the true halophytes use Na as an essential element, they can tolerate the above normal salinity. Many halophytes counteract the aforementioned problems by up taking NaCl from the soil. Fore example, as shown in table 9 sodium concentration ranged between 3.1 and 10.8% in *Atriplex hortensis* and *Tetragonia tetragoioides,* respectively. It is also clear that NaCl removal from the soil ranged between 206 and 2185 kg/ha., by *Atriplex hortensis and Atriplex halimus*, respectively. Concerning NaCl removal from the soil, as shown from table 9 that NaCl removed from the soil ranged between 204 kg/ha. by *Atriplex hortensis and 2185 kg /ha. by Atriplex halimus* (Final report Salt Control Project, 2003).

Table (9): Growing period, %Na in plant dries matter and NaCl uptake

Scientific name	Growth period		Na % DM	NaCl uptake Kg/ha.
	Months	Days		
Beta vulgaris cycla	Oct.- May	120	6.0	389
Cynara cardunculus	Jan.- May	120	3.7	246
Atriplex hortensis	Jan.-April	90	3.1	204
Tetragonia tetragoiodes	Jan.- June	150	10.8	713
Atriplex halimus	Perennial	250	8.25	2185

Source: Final report SaltControl Project, 2003.

From the aforementioned results halophytes can divided into two categories: 1- facultative halophytes that don't require high levels to survive, but can tolerate such conditions. 2- obligate halophytes that actually require higher levels of NaCl in order to exist.

It is of interest to show the great importance of halophytes in friendly, safety cleaning the soil from salinity. Table 10 shows salt added to the soil through irrigation water during the growing period of a crop, salt absorbed by the crop as well as salt remain in the soil (Final report SaltControl Project, 2003).

Using halophytes for forage production on salt-affected soils can markedly decreased the salt after its harvesting (Ashour *el al*., 1999 and 2002). Tables 11 & 12 show the beneficial effect of using such on chemical properties. Ashour *et al*, 2002 also added that killar grass (*Leptochloa fusca)* gave its maximum biomass (fresh and dry) when irrigated with diluted seawater of 10000ppm.

Table (11): Salt applied, salt absorbed in ton/ha. and salt remained in the soil of tomato, lettuce, barley.

	Tomato			Lettuce		
	Applied	Absorbed	Salt remained	Applied	Absorbed	Salt remained
	0	0	0	1.4	0.45	0.95
	7.7	0.24	7.46	4.2	0.25	3.95
	8.6	0.35	8.25	6.3	0.13	6.17
	9.5	0.38	9.12	7.8	0.29	7.51
Total	25.8	0.97	24.83	19.70	1.12	18.58
Mean	8.6	0.323	8.277	4.925	0.28	4.645

Source: Final report SaltControl Project, 2003.

Table (11): Some chemical properties of salt-affected soil before planting and after harvesting of Diplachne Fusca.

	Soluble cations and anions meq/100 g soil						
	EC (dS/m)	Na	K	Ca	Mg	HCO3	Cl
Before planting	17.4	63.6	0.75	15.0	11.0	9.0	67.2
After harvesting	11.2	41.2	2.1	8.8	6.0	3.2	41.7

Source: Ashour *et al*, 1999

Table (12): Chemical properties of soil samples collected from the site of Leptochloa fusco grown at the south of lake Quarun.

Profile depth (cm)	EC (dS/m)	Soluble cations and anions (meq/100g soil)				
		Na	Ca	Mg	HCO_3	Cl
Before transplanting						
(0 – 30)	17.4	127	30	22	18	134
(30 –60)	36.0	224	54	51.6	17.6	243
After two years from transplanting						
(0 – 30)	11.4	82	17.5	12	6.4	83.4
(30 –60)	21.6	134	33	28.6	9.6	146

Source: Ashour *et al*, 2002

El-Fouly *et al*., 2002 found that *Cynara* and *Suaeda* can be cultivated as salt removing species in the salt-affected soils. *Cynara* found to be adaptable to high salt concentration and superior to Suaeda in removing salts from the root medium. In addition, *Cynara* petioles can be used as vegetable and *Suaeda* can be used in some medical purposes

Conclusion and comments

- Since, the addition on nutrients as soil application may either increase or decrease crop salt-tolerance depending upon the level of salinity and the extent by which the nutrient in the system is limiting, nutrient foliar feeding is recommended.
- Concerning, halophytes, scientists need to start learning about halophytes and their potential uses. First, they should create a large bank of halophyte germplasm. Then, they must fine out the different levels of salt tolerance in each plant and catalog them. Thereafter, they can screen them for beneficial properties.
- Saline agriculture using cash crop halophytes must be existed in our agricultural program.
- Halophytes can remove considerable amounts of salt from the salt-affected soils effectively, permanently and cleanly. Using such plants we can save water and decrease soil salinity.

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الاتجاهات الحديثة فى مقاومة الملوحة (بحث مرجعى)

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تعد ملوحة التربة أومياه الرى أحد أهم المشاكل الموجودة فى مناطق البيئة الجافة وشبة الجافة من حيث تأثيرها على نمو وإنتاجية المحاصيل المختلفة. وتحتوى مثل هذه الأراضى على مقدار زائد عن تحمل جذور النباتات من الأملاح الذائبة الكلية مما يسبب ضغطا اسموزيا مرتفعا خارج منطقة الامتصاص والذى يؤدى بدوره إلى ما يسمى ببلزمة خلايا الجذور وعدم استطاعة الجذر على امتصاص الماء والأملاح الذائبة فيه واللازمه لحياة النبات. كما تؤدى الملوحة الزائدة إلى حدوث خلل فى التوازن العنصرى ينتج عنه نقصا فى عنصر ما أو سمية من عنصر آخر .

وللحد من هذه الآثار السلبية هناك العديد من الطرق المتبعة منها ما هو تقليدى ومنها ما هو حديث. وفيما يلى سرد لهذه الطرق.

الطرق التقليدية: وهى مكلفة وتحتاج الا وقت وجهد وتتلخص فى:-

1- غسيل التربة: ويتطلب هذا ان تكون الأرض مستوية ويكون مصدر المياه المستخدمة فى الغسيل منخفض فى محتواه من الأملاح الذائبة كما يتطلب وجود نظام صرف جيد.
2- كشط الأملاح المزهرة على سطح التربة
3- غسيل التربة مع إضافة المصلحات مثل الجبس الزراعى أو الكبريت.

الطرق الحديثة ومنها:

1- التسميد الأرضى والتسميد الورقى: كما سبق القول ، تحت ظروف الإجهاد الملحى يحدث خلل فى التوازن العنصرى يؤدى بدوره الى ظهور نقص فى محتوى النبات من العناصر الكبرى والصغرى على السواء، وظهور سمية من بعض العناصر مثل الصوديوم والكلوريد. وعلية فان الاعتناء بإضافة أسمدة الكالسيوم والبوتاسيوم والأسمدة النتروجينية النتراتية قد تحد من الآثار السلبية للملوحة وتزيد من قدرة النبات فى مقاومة وتحمل الملوحة ، ولقد وجد أن التسميد الورقى بالعناصر الكبرى أو الصغرى يزيد من مقاومة النبات للملوحة من ناحية ويجنب زيادة ملوحة التربة من الناحية الأخرى.

2- زراعة النباتات الهالوفاتية: حيث تعمل هذه النباتات على إزالة قدر كبير من أملاح التربة مما يمكن من زراعتها بالمحاصيل الأخرى الحساسة للملوحة.

الكلمات المفتاحية: الملوحة – كلوريد الصوديوم – العناصر المغذية – التغذية الورقية – النباتات الهالوفاتية