COMBATING THE NEGATIVE EFFECT OF SOIL SALINITY STRESS AT SAHL EL-TINA AREA ON MAIZE GROWTH AND PRODUCTIVITY USING SOME FERTILZATION MANIPULTIONS

Kadria M. El-Azab, Ahmed Kh. Amer, Ibrahim A.E. Hegab and Tarek A. Abou El-Defan
Soils, Water and Environ. Res. Institute, Agric. Res. Center, Giza, Egypt

ABSTRACT:

A field study was conducted on a sandy loam soil that is suffering from salinity stress and Zn-deficient at a newly reclaimed area of Galbana Village No. 7, Sahl El-Tina, North Sinai, Egypt during a growing summer season of 2009 to identify some scientific approaches for alleviating the negative effect of soil salinity stress on the future projects in agricultural utilization. The applied treatments were two solid N-mineral forms (*i.e.*, urea of 46 N% and ammonium sulfate of 20.6 N%) were added at the recommended dose of 120 kg N/fed as soil application as well as three liquid mixtures of (1.0 g K-humate of 85 % + 0.5 g Zn SO_4, which dissolved in 1 L water), (0.5 g Zn SO_4 dissolved in 1 L of soaking water extract of compost tea) and (0.75 g $ZnSO_4$ dissolved in 1 L water) were added at two equal doses of 300 L/fed for each one either as foliar spray on plants or as soil application on the soil rows of growing plants. Maize (*Zea mais* L., Three cross 321 cv.) was undertaken as plant indicator to identify its possible response to grow under soil salinity stress of Sahl El-Tina area as well as the relationship between either maize yield or grain quality and the expected amelioration process in the experimental soil properties as a result of the applied treatments.

The obtained results indicated that the experimental soil could be classified as "Typic Torriorthents, loamy skeletal, mixed, thermic". Also, wetness, soil texture, $CaCO_3$, gypsum and salinity/alkalinity represent the main limitations for soil productivity, with an intensity degree of moderate (65-75%), for wetness, soil texture and salinity/alkalinity as well as slight (90-85 %) for the other ones. The suitability classes for irrigated agriculture land in both current and potential conditions could be belong the marginally (S3ws$_1$n) and moderately (S2s$_1$) suitable classes, respectively. Moreover, the resultant adaptations of soil suitability class for cultivating maize plants could be considered as marginally suitable (S3s$_1$n), and limiting factors of soil texture and salinity/alkalinity in the current condition. Soil suitability becomes a moderately suitable (S2s$_1$) in the potential condition, and soil texture still becomes a limiting factor.

The obtained results showed also that the studied maize plant parameters such as growth characters (*i.e.*, nutrient contents uptake by leaf tissues), ear characters (*i.e.*, length and diameter), biological yield (*i.e.*, grain and stalk yields fed^{-1}), grain quality (*i.e.*, weight of 100 kernels and crude protein %) and grain nutritional status (*i.e.*, N, P, K, Fe, Mn and Zn contents) were recorded the best values at the applied rates of ammonium sulfate as a main source of N-mineral as compared to the same applied rats of urea. In addition, the liquid fertilizer mixture of (0.5 g Zn SO_4 dissolved in 1 L of soaking water extract of compost tea) surpassed the other applied two mixtures for the previous plant parameters. Moreover, the applied liquid fertilizer mixtures, in general, were more effective on plant parameters when added as soil application on soil rows of grown plants as compared with directly foliar spray on plants.

Thus, fertilizing maize plants with ammonium sulfate should be enhanced soil availability of plant nutrient, due to the effective role of both accompanied cationic (NH_4^+) and anionic (SO_4^{2-}) forms. However, the applied N- NH_4^+ causes a N-soil potentially safe over a wide range due to lower risks of volatilization, leaching and de-nitrification losses as well as lowering soil pH due to for the SO_4^{2-} ions. Also, it was found that both soaking water extract of compost tea and K-humate as a soil liquid fertilizer are not only considered as a strategic storehouse for essential plant nutrients but also enhancing nutrients uptake, reducing the uptake of some toxic elements and supporting Zn-deficient as well as improving the nutrients balance in the soil solution and many of the physiological processes in plants under soil salinity stress. Such favourable conditions were positively reflected on ameliorating maize growth parameters and grain yield with high quality of nutritional status.

Key words: Maize, saline soil, N-mineral, K-humate, urea, ammonium sulfate and soil salinity stress.

INTRODUCTION:

Salinity is a major factor limiting the crop productivity in most areas of the World, especially in arid and semi-arid regions as a result of high evaporation and inappropriate irrigation techniques **(Khan and Duke, 2001)**. Salinity problem is defined as a condition where the salts in solution within the crop root zone accumulate in high concentrations which decrease crop yield **(Ayers and Westcot, 1985)**. Salts in the soil water solution can reduce extraction of soil available nutrients and water uptake by roots of growing plants, and then reduce the quality and yield of crops **(Allen *et al.*, 1998)**. Salinity, either of soil or of irrigation water causes disturbances in plant growth and nutrient balance, through its effects on plant physiology and its changes on water and ionic status in the cells. Thus, ionic imbalance occurs in the cells due to excessive accumulation of Na^+ and Cl^- and reduces uptake of other mineral nutrients, such as K^+, Ca^{2+} and Mn^{2+} **(Hasegawe *et al.*, 2000 and Tester and Davenport , 2003).**

Exploiting saline soils in growing crops, especially cereal crops, can be sharing in solve the problem of shortage in food production, to face the demand of fast growing population. The most problem of exploiting saline water in agriculture is how to ensure sufficient requirements of necessary macro and micro-nutrients for growing plants and correct their deficiencies. This goal can be possible by using some fertilization manipulations, fertilizing growing crops with some certain formulations of micronutrients as well as applying some liquid forms of organic fertilizers either to soil or by spraying on growing plants. Fertilization plays an important role in promoting plants to tolerate salt stress and toxicity **(Ghoulam *et al.*, 2002)**. On the other hand, plant response to fertilizers depends on severity of salt stress in the root zone and application of fertilizers to saline soils may exacerbate soil salinity conditions **(Maas and Grattan, 1999)**.

Nitrogen is usually the most growth limiting plant nutrient in saline or in non-saline soils. Many investigations on salinity-nitrogen issue were focused either on nitrogen influence on plant **(*i.e.*, Ozer *et al.*, 2004 and Svoboda and Haberle, 2006)** or on salinity as limiting plant growth factor **(*i.e.*, Burger and Celkova, 2003; Orak and Ateş 2005 and Supanjani and Lee, 2006)**. Most salinity and nitrogen interaction studies have been conducted on saline soils that were deficient in N. Therefore, application of N fertilizers improved growth and/or yield of maize, wheat grown on saline soils **(Soliman *et al.*, 1994)**. Some studies also indicate that maize and cotton dry matter decreased by increasing salinity but increases by N application **(Homaee *et al.,* 2002)**. In salinity and nitrogen interactive studies, the form in which N is supplied is important. **Tshivhandekano and Lewis (1993)** showed that NH_4^+-fed wheat and maize were more sensitive to salinity than NO_3^--fed plants when grown in solution culture.

Recently attention was given to use other new technologies of combating salinity, among them the use of foliar sprays to increase plant tolerance to salinity. Many works indicated that applying nutrients by foliar application increases tolerance of growing plants to salinity by alleviating Na^+ and Cl^- injury to plants **(El-Fouly *et al.*, 2002 and El-Fouly *et al.*, 2004)**. However, it was found that 2000 and 5000 mg kg^{-1} soil NaCl inhibited growth and nutrient uptake by faba bean plants, while spraying micronutrients either before or after the salinity treatments could restore the negative effect of salinity on dry weight and nutrients uptake of plants **(El-Fouly *et al.*, 2010)**.

K-humate is a richly nutritious black granule with entire soluble in water. **Varanini and Pinton (1995)** summarized the effects of humic substances (*i.e.*, K-humat) on plant growth and mineral nutrition under pointing out the positive effects on seed germination, seedling growth, root growth, shoot development and the uptake of macro and microelements. He continued, humic substances countered the toxic effect of NaCl, resulting in greater yield. This could be explained by the influence of the chelating affect of humic acids with iron, zinc, manganese and calcium etc. Also, **KuliKova *et al.* (2005)** pointed out that humic substances might show anti-stress effects under abiotic conditions stress (unfavorable temperature, pH, salinity, etc.) either added as soil application or as spraying on plants. Humic substances may enhance the uptake of nutrients and reduce the uptake of some toxic elements.

Therefore, it could be said that the application of humic substances could be improved plant growth under the conditions of soil salinity. Consequently, the use of humic substances has often been proposed as a soil amendment for improving crop production, especially under soil stress conditions **(Adani *et al*., 1998)**. In addition, compost tea was used since few years ago, mainly due to its benefit from the steeping liquids of compost heaps. Also, it's easily made by soaking or steeping compost in water. The resulting compost tea is used either as foliar spray on the plants or as soil application. Thus, compost tea can increases plant growth, provides nutrients to both plants and soil as well as help growing plants to resist salinity and other toxic effects.

The present work was aimed at assessing the positive effects of some fertilization manipulations, *i.e.*, solid N-mineral forms as soil application as well as some liquid micronutrients and organic amendments of K-humate and compost tea either added as foliar spray or soil application on plant growth, grain yield and quality of maize under soil salinity stress and Zn-deficient of Sahl El-Tina area, North Sinai, Egypt.

MATERIALS AND METHODS:

To achieve the aforementioned target, a field experiment was conducted on a sandy loam soil that is suffering from salinity stress and Zn-deficient at a newly reclaimed area of the Galbana Village No. 7, Sahl El-Tina, North Sinai, Egypt during a growing summer season of 2009. Some physical and chemical properties of the experimental soil, which were determined according to the described standard methods after **Black *et al.* (1965), *Page et al.* (1982) and Klut (1986),** are presented in Table (1).

Table (1): Some physio-chemical and fertility characteristics of the studied soil.

Soil characteristics	Value	Soil characteristics.	Value
Particle size distribution %		ESP	12.65
Coarse sand	19.8	ECe in dS m^{-1} (*Soil paste extract*):	7.55
Fine sand	55.4	*Soluble ions in soil paste extract(m molc L^{-1}):*	
Silt	8.7	Ca^{++}	17.45
Clay	16.1	Mg^{++}	13.35
Soil texture class	SL*	Na^{+}	45.50
$CaCO_3$ %	7.98	K^{+}	0.70
Gypsum %	0.74	CO_3^{--}	0.00
Organic matter %	0.85	HCO_3^{-}	2.75
pH (1:2.5 soil water suspension)	8.04	Cl^{-}	30.90
		SO_4^{--}	43.35

Available macro and micronutrients (mg/kg soil)

N	P	K	Fe	Mn	Zn
32.50	5.64	179.50	5.87	1.94	0.76

Critical levels of nutrients after Lindsay and Norvell (1978) and Page et al. (1982)

Limits	N	P	K	Fe	Mn	Zn
Low	< 40.0	< 5.0	< 85.0	< 4.0	< 2.0	< 1.0
Medium	40.0-80.0	5.0-10.0	85.0-170.0	4.0-6.0	2.0-5.0	1.0-2.0
High	> 80.0	> 10.0	> 170	> 6.0	> 5.0	> 2.0

*SL=Sandy loam

The experimental soil is also irrigated with a saline water (a mixture of the fresh Nile water and agricultural drainage one) derived from one of El-Salam Canal. The chemical characteristics of irrigation water were carried out according to the described methods after **Page *et al.* (1982)**, as shown in Table (2).

Table (2): Chemical characteristics of the used irrigation water.

pH	ECiw (dS/m)	Soluble cations (m molc L^{-1})				Soluble anions (m molc L^{-1})				SAR
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	
8.04	1.45	2.67	3.43	8.25	0.45	0.00	4.45	7.70	2.65	4.71

According the suitability criteria for irrigation water undertaken by **Ayers and Westcot (1985)**, the used irrigation water source could be classified as a second class for water salinity (ECiw=0.75-3.00 dS/m) and first one (SAR <6) for sodicity (C2S1), denoting an increase problem for soil salinity (C2) and no sodicity one (S2) are expected. According to calculation of crop water requirements and soil leaching requirement, irrigation was done every 8 days till crop maturity to avoid the detrimental effects of high osmotic potential of saline soil solution.

The experimental soil plots were arranged in a split-split plots design with three replicates. The area of each soil plot was 21.0 m^2 (3.5 m width x 6.0 m length). Experimental soil plots were ploughed twice in two ways for seed bed preparation after received local manufacture organic manure at a rate of 15 m^3/fed and superphosphate fertilizer (15.5 % P_2O_5) at a rate of 200 kg fed^{-1} on 10 days before planting. Also, potassium sulfate (48 % K_2O) was added as foliar spray two times, *i.e.,* 25 and 50 days of sowing plants, however, 1.0 % of potassium sulfate (K_2SO_4) at a rate of 5 L/plot.

The tested treatments were applied as follows:

a. Control, where the recommended dose of N-mineral was added at a rate of 120 kg N fed^{-1}, either in the form of urea [$(NH_2)_2 CO$, 46 % N] or ammonium sulfate [$(NH_4)_2 SO_4$, 20.6 % N].

b. Liquid fertilizer mixtures, which included four treatments as follows:

L_0: No liquid fertilizers.

L_1: (1.0 g K-humate of 85 % + 0.5 g Zn SO_4, which dissolved in 1 L water).

L_2: (0.5 g Zn SO_4 dissolved in 1 L of compost tea that prepared from soaking extract of organic compost in water).

L_3: (0.75 g $ZnSO_4$ dissolved in 1 L water).

Both of N-mineral fertilizer forms and liquid fertilizer mixtures were assigned to the main and sub-main plots, respectively. Each of the N-mineral fertilizer form was added in two equal doses after 25 and 50 days from planting. Also, the application of liquid fertilizer mixtures were added at two times of 25 and 50 days from sowing, with rate of 300 L/fed for each time either foliar spray on plants or on the soil rows of growing maize plants. These mixtures were assigned to the sub-sub plots, and the replicates were distributed randomized inside their experimental plots.

It is well known that poor maize seed germination is a major problem in saline soils, however, seed vigour enhancement treatments might be able to alleviate the negative effects of salinity **(Janmohammadi *et al.,* 2008)**. Thus, the treatment of seed soaking before sowing in a certain diluted solutions can face the problem of salt stress through invigoration seeds. Such treatment of treated seeds improves germination, and then enhancement competency of seeds to grow under soil saline conditions **(Pegah *et al.,* 2008 and Mahatma *et al,* 2009)**. Therefore, the grains of maize (*Zea mais* L., Three cross 321 cv.) were soaked for~18 hours in 2 % urea solution before their planting in the experimental field through the studied growing summer season of 2009. All the agronomic practices were followed according to the usual methods adopted for maize planting in the area of Galbana Village.

Harvest was done at complete crop maturity, where ear lengths (cm) and diameters (cm) were measured for each experimental plot. Ears, leaves and stalks were air-dried, and then 100 grains weight (g), grain yield (kg/fed), leaves and stalks yields (kg/fed) were estimated for each experimental plot. Also, the samples of maize grain, leaves and stalks were collected from every experimental treatment, oven-dried at 70C°, crushed and wet digested using a mixture of H_2SO_4 + $HClO_4$ acids to determine nutrient contents in aliquots of the digested solutions, *i.e.,* N, P, K (%), Fe and Zn in µg/g^{-1} **(Ryan *et al.,* 1996)**.

Available nutrients (*i.e.,* N, P, K, Fe and Zn as mg kg^{-1} soil) were determined in the surface soil layer (0-30 cm) for each plot **(Cottenie *et al.,* 1982)**. The obtained data were exposed to proper statistical analysis of variance (ANOVA) by using Minitab computer program and least significant differences (LSD) values were calculated at levels 5 % **(Barbara and Brain, 1994)**.

RESULTS AND DISCUSSIONS:

I. A general view on the experimental soil:

The experimental sandy loam soil represents a newly reclaimed soil of the scattered Private Farms at the North Sinai areas that are mainly encompassing the fluvio-marine plain of sandy loam in texture. It is developed under climatic conditions of long hot rainless summer and short mild winter, with scarce amounts of rainfall. Data illustrated in Table (1) indicate that the ECe value was 7.55 dS m^{-1}

as well as ESP value was 12.65 %, hence the studied soil was surveyed as moderately saline and non-sodic one. Such results are emphasized by the progressive increments of soluble Na^+, which surpassed the soluble (Ca^{2+} + Mg^{2+}) contents that reflected the signs of unfavourable soil aggregation, with weak granular as a structure type. In addition, the field work showed that the studied soil profile at the experimental site was characterized by a moderate effective soil depth of 80 cm due to the occurrence of water table.

The analytical data in Table (1) reveal that the studied sandy loam soil attains a relatively moderate $CaCO_3$ content. In addition, the prevailing hot and arid climatic may be ascribed to the low accumulated plant residues (low organic matter content) and soil pH tended to be the alkaline side. As for soil fertility status, the studied soil was mostly suffering from Zn-deficient, according to the critical levels of the studied available nutrients after **Lindsay and Norvell (1978) and Page *et al*. (1982),** due to the skeletal nature of such desert sandy loam soil that is poorer in nutrient-bearing minerals. Thus, supplying Zn as an essential micronutrient is undoubtedly of great importance.

II. Soil taxonomic unit:

According to the obtained results of field work and physio-chemical characteristics as well as based on the outlines of classification system **(USDA, 2006)**, the experimental soil could be classified at a family level of “Typic Torriorthents, loamy skeletal, mixed, thermic".

III. Soil evaluation for agricultural irrigated land:

A parametric system of soil evaluation, undertaken by **Sys and Verheye (1978)**, was applied to define the limitations for soil productivity, their intensity degrees and suitability classes for irrigated agriculture land, as shown in Table (3). The obtained data show that wetness (w), soil texture (s_1), $CaCO_3$ (s_3), gypsum (s_4) and salinity/alkalinity (n) represent the main limitations for soil productivity, with an intensity degree of moderate (65-75%) for wetness, soil texture and salinity/alkalinity as well as slight (90-95%) for the other ones. Also, the suitability classes in the current and potential cases of the studied soil could be categorized as a marginally suitable for irrigated agriculture land ($S3s_1n$) in case of the current condition and a moderately suitable ($S2s_1$) in case of potential one, with suitability index rating (Ci) ranged 29.18 and 55.6 %, respectively.

IV. Soil suitability for maize plants:

Firstly, land suitability for agricultural irrigated soils is the appraisal of specific areas of land from a general point of view without mentioning the specific kind of use.

Table (3): Soil limitations and rating indices for evaluating the studied soil.

Suitability condition	Topography (t)	Wetness (w)	S				Soil salinity/ Alkalinity (n)	Rating (Ci)	Suitability class	Suitability subclass
			Soil texture (s_1)	Soil depth (s_2)	$CaCO_3$ (s_3)	Gypsum (s_4)				
Current	100	70	65	100	95	90	75	29.18	S3	$S3ws_1n$
Potential	100	100	65	100	95	90	100	55.60	S2	$S2s_1$

So, some soils may be suitable for a specific crop and unsuitable for another. The ideal approach for land evaluation is based on evaluating the land for utilization types which used as guides for the most beneficial use for a specific productivity by replacing a less adapted land utilization type by another promising one. Also, the evaluation indices of land characteristics are done by rating them and specifying their limitations for certain crops by matching the calculated rating with the crop requirements in different suitability levels as proposed by **Sys *et al.* (1993)**. In the studied area, without major land improvements, the crop requirements were matched with the present land qualities for processing the current and potential land suitability of the different land units. This approach enables management of different alternatives for specific utilizations that are adapted to the existing limitations to give maximum output. The suitability classes of the experimental soil, either in the current or potential condition, for the cultivation of maize plants are shown in Table (4).

Table (4): Soil suitability for cultivation of maize plants.

Condition	Topography (t)	Wetness (w)	S				Soil salinity/ Alkalinity (n)	Rating (Ci)	Suitability class and sub-class
			Soil texture (s_1)	Soil depth (s_2)	$CaCO_3$ (s_3)	Gypsum (s_4)			
Current	100	90	75	100	90	100	50	30.37	$S3ws_1n$
Potential	100	100	75	100	90	100	100	67.50	$S2s_1$

As for this purpose, the land utilization is applicable for the main characteristics of the studied area, which are considered regarding land qualities of drainage, salinity and sodicity. Moreover, the resultant adaptations of soil suitability class for cultivating maize plants could be considered as marginally ($S3ws_1n$) and moderately suitable ($S2s_1$) adaptation in the current and potential conditions, with a rating index of 30.37 and 67.50 %, respectively. Also, wetness (w), soil texture (s_1), $CaCO_3$ content % (s_3) and salinity/alkalinity (n) represent the main limitations for soil productivity in the current condition, with an intensity degree of moderate (50-75 %) for s_1 and n as well as slight (90 %) for wetness and $CaCO_3$ content %. As for the potential condition, soil salinity/alkalinity should be corrected, but both soil texture (s_1) and $CaCO_3$ (s_3) will be remained as permanent soil limitations, and then the resultant adaptations of soil suitability class for cultivating maize plants could be considered as moderately suitable ($S2s_1$), with a rating index of 67.50 % and a soil texture as a limiting factor for soil productivity.

III. Response of some soil available nutrient contents to the applied treatments:

Data in Table (5) showed an obvious clear response for some soil available nutrient contents to the applied treatments (75 days after planting), particularly both the treatments of solid N-mineral fertilizers as N-source and liquid fertilizer mixtures that attained compost tea and K-humate for all plant essential nutrients as well as that attained $ZnSO_4$ for Zn only.

Table (5): Effect of applied treatments on some soil available nutrients status.

N-mineral form (N)	Liquid fertilizer mixture (L)		Soil available nutrient contents (mg kg^{-1} soil)					
	Treatment	Method	N	P	K	Fe	Mn	Zn
Initial soil state			32.50	5.64	179.50	5.87	1.94	0.76
Urea (N1)	L_0	--	46.85	5.75	183.40	5.92	1.98	0.81
	L_1	Foliar	51.13	5.97	187.17	5.97	2.14	0.94
		Soil	54.02	6.45	191.61	6.25	2.52	1.12
	L_2	Foliar	57.25	6.05	189.05	6.10	2.30	0.98
		Soil	71.84	6.89	198.78	6.73	2.75	1.35
	L_3	Foliar	49.90	5.80	181.25	5.95	2.17	0.96
		Soil	50.05	5.86	183.09	6.02	2.25	1.82
Ammonium sulfate (N2)	L_0	--	70.47	5.84	189.35	5.98	2.00	0.87
	L_1	Foliar	76.20	6.02	190.70	6.04	2.35	0.99
		Soil	80.65	6.57	195.10	6.38	2.78	1.40
	L_2	Foliar	86.00	6.18	194.20	6.19	2.55	1.14
		Soil	92.32	7.05	215.95	6.87	3.05	1.63
	L_3	Foliar	74.00	5.85	183.40	6.00	2.29	1.07
		Soil	76.65	5.90	185.39	6.08	2.37	1.95
Statistical analysis								
L.S.D. at 0.05	N-forms< N		1.87	0.13	9.55	0.31	0.09	0.10
	Liquid component, L		1.75	0.29	6.67	0.19	0.08	0.09
	Applied method, M		1.03	0.53	10.14	0.08	0.06	0.11
	N x L		1.21	0.31	7.87	0.17	0.05	0.10
	N x M		0.68	0.17	11.26	0.15	0.04	0.13
	L x M		1.28	0.22	11.35	0.18	0.11	0.12
	N x L x M		1.15	0.71	7.74	0.13	0.10	0.69

The previous trend of ammonium sulfate is coinciding with the concepts of **Breitenbeck *et al.* (1980) and Below *et al.* (2009)** who decided that ammonium sulfate known as a potentially safe applied N-source over a wide range of crop production conditions. This advantage is largely because of their lower risk of volatilization losses as compared to N fertilizers containing urea, and to their lower risk of leaching or de-nitrification losses as compared to fertilizers containing N-nitrate. In general, the beneficial effect of compost tea on increasing available nutrient contents in the soil may be attributed to it is not only considered as a chelating agent through enhancing the released active organic acids and as a storehouse for plant essential nutrients but also to be a strategy to preserve these nutrients from lose vs their easily uptake by maize plants. In addition, the slow nutrients release during the decomposition and mineralization processes of these organic substances resulted in minimizing their possible lose by leaching throughout the studied relatively coarse textured soil **(Mohammed, 2004)**.

Moreover, humic substances have widely been regarded as playing a beneficial role in macro- and micro-nutrients acquisition by plants, however, the applied K-humate was more pronounced for nutrients availability in the soil, may be the occurrence of active organic acids that enhancing the solubilization of nutrients from the native and added sources. Also, the chelating affect of humic substances with micronutrients is mainly because of its complex properties which increased the availability of plant essential nutrients in sparingly soluble hydroxides form **(Nardi *et al*., 2002).** At the same times, humic substances also might show anti-stress effects under a biotic condition stress (unfavorable temperature, pH, salinity, etc.) either added as soil application or as spraying on plants, and then it enhances the uptake of nutrients and reduces the uptake of some toxic elements.

As a general trend date showed that, there were insignificant effects between urea and ammonium sulfate on the contents of available contents of P and K. But soil treated with ammonium sulfate contained available contents of P, K, Fe and Zn more than those treated with urea. That was true, since the accompanied anion of SO_4^{2-} was more affect on reducing soil pH, and in turn encouraging the availability of plant essential nutrients, especially phosphorus and micronutrients. It is noteworthy to mention that there was a significant difference between the methods of application as related to their effects on the available nutrient contents of the soil. However, spraying the liquid fertilizer mixtures on the soil rows of growing plants caused pronounced increases in all available nutrient contents under study as compared to the method of foliar spray on maize plants.

IV. Response of the nutritional status of maize leaves and stalks to the applied treatments:

Data in Table (6) showed that macronutrient N, P and K contents % as well as micronutrient Fe, Mn and Zn as mg kg^{-1} of maize leaves and stalks in the maximum growth stage (75 days after planting) significantly increased as a general trend with increasing the applied rates of ammonium sulfate as compared to those received the same rates of urea. The favourable effect of ammonium sulfate as compared to urea was emphasized by the previous results outlined by **Breitenbeck *et al.* (1980), Tshivhandekano and Lewis (1993) and Below *et al.* (2009)**. These increases were maximized when the N-mineral forms were applied in combination with liquid fertilizer mixtures, particularly which included soaking water extract of the used organic tea, *i.e.*, treatment of L_2, followed by L_1 that contains K-humate. The superiority effect of soaking water extract of the used organic tea is more associated with to the relatively high contents of both essential macro- and micro-nutrients (N, P, K, Fe, Mn, Zn and Cu).

On the other hand, the applied treatment of L3 was usefulness for the released available nutrients, except of either Zn-uptake or Zn-content, which in turn reflected on the relatively less contents for the other nutrients in maize leave and stalk tissues. These findings are emphasized by the technical theory of elemental balance between the available nutrients in the soil solution that is achieved an easily nutrients uptake by plant roots than occurs a dominance of individually one due to the antagonism phenomenon. That was true, since there were narrow differences between Zn-contents in maize leaves and stalks for both applied foliar spray and soil methods.

In contrast, the superiority of treated plants with liquid fertilizer mixtures included either soaking water extract of the used organic tea or K-humate was more attributed to the stimulatory effect of humic substances which have been directly correlated with enhance nutrients availability from either the added or native sources as well as their mobility in the soil and easily uptake by the grown plants **(Caccco *et al*., 2000 and Delfine *et al*., 2005)**. Such surpassed effect of both applied organic substances is more associated with to the relatively high contents of both essential macro- and micro-nutrients and the released active organic acids that enhancing more released micronutrients or their solubilization from both native or added sources as well the ameliorated soil-moisture regime and the biological condition that are keeping them in as a storehouse of organo-metalic forms for extended period and their mobility for uptake by plant roots. Also, these results are in agreement with those reported with **Maggio *et al.* (2006)** who mentioned that such organic substances control many stress adaptation responses including stomatal closure, osmotic adjustment, ion compartimentation, regulation of shoot versus root growth and modifications of root hydraulic conductivity properties.

Table (6): Effect of applied treatments on leaf and stalk nutrient contents.

N-mineral form (N)	Liquid fertilizer mixture (L)		Macronutrients %			Micronutrient (mg kg^{-1} dry weight)		
	Treatment	Method	N	P	K	Fe	Mn	Zn
Urea (N1)	L_0	--	2.18	0.23	2.07	224.5	97.0	15.2
	L_1	Foliar	2.54	0.34	2.42	287.7	135.4	27.1
		Soil	2.73	0.37	2.59	311.0	149.6	26.4
	L_2	Foliar	2.90	0.41	2.54	325.3	163.9	30.2
		Soil	3.15	0.45	2.76	356.1	181.4	29.3
	L_3	Foliar	2.40	0.29	2.25	265.8	120.9	32.0
		Soil	2.45	0.31	2.32	270.6	126.2	30.8
Ammonium sulfate (N2)	L_0	--	2.40	0.27	2.19	243.4	112.8	18.1
	L_1	Foliar	2.85	0.37	2.60	309.6	144.3	32.3
		Soil	3.12	0.42	2.71	337.5	163.7	31.5
	L_2	Foliar	3.29	0.46	2.85	358.9	174.5	34.7
		Soil	3.76	0.53	3.07	395.5	192.0	33.4
	L_3	Foliar	2.46	0.31	2.30	276.1	125.1	35.0
		Soil	2.50	0.33	2.37	280.0	130.6	33.5
Statistical analysis								
L.S.D. at 0.05	N-forms< N		0.19	0.01	0.014	9.81	13.06	1.75
	Liquid component, L		0.14	0.05	0.012	14.75	7.74	1.23
	Applied method, M		0.07	0.07	0.08	11.18	14.05	1.36
	N x L		0.08	0.04	0.10	7.73	7.21	1.10
	N x M		0.12	0.03	0.011	8.25	11.18	0.71
	L x M		0.08	0.05	0.04	11.05	10.34	0.58
	N x L x M		0.13	0.07	0.07	8.32	12.41	0.97

In general, the favourable effect of the liquid fertilizer mixtures, particularly in case of soil application was commonly achieved due to lowering soil pH that improving nutrients availability, mobility, reliability and ability to uptake by plant roots. This beneficial effect could be explained by many aspects, *i.e.*, besides an increase in the released either macro- or micro-nutrient contents through the decomposition of the applied manures, there was a reduction in nutrient fixation and forming the stable complexes of micronutrients-humic substances supplied from such manures and keeping them in available forms for extended period **(Shanmugam and Veeraputhran, 2001)**. It is noteworthy to mention that the nutrient contents in plant tissues were, in general, extending parallel close to the corresponding available nutrient contents in the studied soil, as shown in Table (5). The superlative of such liquid fertilizer mixtures as foliar application, as a scientific result in this study, was confirmed by many of the previous scientific studies undertaken by **El-Fouly *et al.* (2002), El-Fouly *et al.* (2004) and El-Fouly *et al.* (2010)** who reported that the humic substances either directly added as foliar spray or released from decayed soil organic matter play an important role in encourage nutrients uptake, especially under saline conditions.

V. Some parameters of either maize ear or grain quality and biological yield as affected by the applied treatments:

As clarified in Table (7), soil fertilization with ammonium sulfate was more effective on either maize ear (*i.e.*, length and diameter) or grain quality parameters (*i.e.*, weight of 100 kernels and crude protein %) and biological yield (*i.e.*, stalk and grain yields) as compared to fertilization with urea. The beneficial effects of the applied treatments were greatly supported by the values of ear characters, biological yield and grain quality, as shown in Table (7), which can be explained on the basis that the treated soil plots with N-mineral and liquid fertilizer mixtures became enriched in the released nutrient contents, which are involved directly or indirectly in formation of starch, protein and other biological components through their roles in the respiratory and photosynthesis mechanisms as well as in the activity of various enzymes **(Nassar *et al*., 2002)**. Such positively effects are reflected on soil productivity and returned on increasing the biological nutrients uptake by maize, and then increasing maize grain yield and its quality.

Also, the applied liquid fertilizer mixtures are enrichments in both organic and mineral substances essential to plant growth and activating the bio-chemical processes in plants, *i.e.*, respiration, photosynthesis and chlorophyll content, which increased the grain quality and quantity **(Hegazi, 2004)**. However, the obtained data showed that the applied treatments to the studied soil, which is characterized by a relatively coarse texture and suffering from either salinity or sodicity, increased the biological yield of maize (*i.e.,* grain and stalk yields). It is noteworthy to mention that these increases were attributed to improve soil capacity to gradually liberate available plant nutrients that are still in maintained active forms for uptake by plant roots. That mean an integrated supply of nutrients through organic and inorganic sources could be an effective practice of nutrient management by reducing inorganic nutrient losses. In general, the optimum ear and grain quality parameters as well as grain and stalk yields of maize were extending parallel close to the corresponding available nutrient contents in the soil, as shown in Tables (5 and 7). Thus, the positive roles of the applied treatments are more attributed to improve the efficiency of either nutrients released or uptake and enhancing dry matter yield, and in turn the grain yield and quality of maize.

Data also declared that, the application liquid fertilizer mixtures as foliar spray on the soil rows of growing plants had the superiority positive effect on the studied ear, grain yield and quality of maize, especially under saline soil condition. Such favourable conditions may be attributed to their causing a lot of positive effects on seed germination, seedling growth, root growth, shoot development as well as improve many physiological processes in plants under soil salinity stress as stated by **Varanini and Pinton (1995), Adani *et al.* (1998) and KuliKova *et al*. (2005)**. In this concern**, El-Fouly *et al.* (2002) and El-Fouly *et al.* (2010)** pointed out that the use of foliar sprays of some nutrient sources caused a positive effect in combating soil salinity hazards on growing plants.

VI. Grain nutritional status as affected by the applied treatments:

The results of grain nutritional status as affected by the applied treatments are extending parallel close to the corresponding available nutrient contents in the soil as well as those accumulated in the leave and stalk tissues of maize, as shown in Table (8).

Table (7): Effect of applied treatments on maize ear parameters and yield components.

N-mineral form (N)	Liquid fertilizer mixture (L)		Maize ear parameter		Biological yield (kg fed^{-1})		Maize grain quality parameter	
	Treatment	Method	Length (cm)	Diameter (cm)	Leaves & stalks	Grain	Weight of 100 kernels, g	Crude protein %
Urea (N1)	L_0	--	17.35	5.17	3457	2275	32.70	6.38
	L_1	Foliar	19.87	5.70	3985	2764	40.17	7.94
		Soil	21.32	6.14	4045	2891	41.56	8.19
	L_2	Foliar	22.45	5.93	4172	2987	42.92	9.06
		Soil	23.78	6.29	4382	3125	43.47	9.63
	L_3	Foliar	18.45	5.38	3574	2454	36.80	7.18
		Soil	19.20	5.57	3698	2557	37.94	7.44
Ammonium sulfate (N2)	L_0	--	18.65	5.39	3578	2365	34.92	7.00
	L_1	Foliar	21.70	6.08	4112	2874	42.05	8.31
		Soil	23.12	6.42	4205	2904	43.85	9.06
	L_2	Foliar	24.56	6.40	4357	3097	44.20	9.75
		Soil	25.47	6.63	4581	3215	45.74	10.94
	L_3	Foliar	19.85	5.51	3674	2593	37.70	7.37
		Soil	20.64	5.72	3715	2645	38.36	7.69
Statistical analysis								
L.S.D. at 0.05	N-forms, N		0.73	0.18	137.80	124.80	1.25	0.65
	Liquid component, L		1.36	0.15	111.15	112.45	1.11	0.62
	Applied method, M		0.77	0.17	90.35	99.45	0.98	0.72
	N x L		0.74	0.16	94.25	87.10	1.30	0.78
	N x M		0.70	0.15	130.00	83.85	0.72	0.73
	L x M		0.79	0.14	189.15	111.15	0.76	0.71
	N x L x M		0.77	0.13	103.35	130.00	1.03	0.65

Table (8): Effect of applied treatments on grain nutrient contents.

N-mineral form (N)	Liquid fertilizer mixture (L)		Macronutrients %			Micronutrient (mg kg^{-1} dry weight)		
	Treatment	Method	N	P	K	Fe	Mn	Zn
Urea (N1)	L_0	--	1.02	0.22	1.47	105.4	38.8	9.2
	L_1	Foliar	1.27	0.34	1.75	134.5	52.1	19.1
		Soil	1.31	0.38	1.84	146.3	57.6	18.4
	L_2	Foliar	1.45	0.42	1.80	152.2	63.7	20.8
		Soil	1.54	0.47	1.96	167.8	70.0	19.7
	L_3	Foliar	1.15	0.30	1.60	124.6	46.9	22.2
		Soil	1.19	0.33	1.65	126.0	49.2	20.8
Ammonium sulfate (N2)	L_0	--	1.12	0.27	1.56	114.9	43.4	11.6
	L_1	Foliar	1.33	0.39	1.85	145.4	55.7	22.9
		Soil	1.45	0.45	1.92	158.7	62.9	21.4
	L_2	Foliar	1.56	0.47	2.04	168.1	67.5	23.0
		Soil	1.75	0.51	2.18	185.0	74.3	22.1
	L_3	Foliar	1.18	0.32	1.64	129.5	48.0	24.6
		Soil	1.23	0.35	1.70	132.3	50.4	23.5
Statistical analysis								
L.S.D. at 0.05	N-forms< N		0.06	0.01	0.07	8.12	1.87	1.43
	Liquid component, L		0.07	0.04	0.06	7.28	2.01	2.40
	Applied method, M		0.19	0.06	0.08	6.56	1.75	2.66
	N x L		0.14	0.09	0.04	6.17	0.71	1.75
	N x M		0.08	0.08	0.05	7.86	1.69	1.36
	L x M		0.15	0.04	0.06	9.94	1.62	1.23
	N x L x M		0.13	0.06	0.09	7.86	1.23	1.30

The significantly response of nutrient contents in maize grain to the applied N-mineral forms in combination with liquid fertilizer mixtures may be due to increased root growth and utilization of the released nutrients along the different growth stages enable the grown maize plants to absorb more nutrients, and then to accumulate in maize grains. Such positive effects are more related to minimize the salinity level of the experimental soil as well as to provide an adequate environmental for plant roots. In this connection, it is found that either released active organic acids or humic acid drastically reduced anions sorption either when added with them or introduced before **(Daif *et al.*, 2004)**. Also, **Abou-Zied *et al.* (2005)** reported that application of humic acid, as an organic soil amendment used either individually or together others, resulted in a significantly increase in crop yield and its components in the relatively coarse texture soils. This is due to its positive effects on improving hydrophysical properties and nutrients availability in such soils as well as a favourable soil media for the nutrients uptake by the grown plants.

It is noteworthy to mention that the ability of both released active organic and humic acids, which included in the applied fertilizer mixtures, for increasing grain nutrient contents is due to its chelating property, which makes the nutrients more available to plant uptake as well as owing to its ability to enhance cell permeability that making a more rapid entry of nutrients into plant cells. Also, such organic substances can also reduce the surface tension of water and increase the effectiveness of nutrients or chemicals. Thus, the increases in N, P, K, Fe, Mn and Zn uptake were due to the frequent application of these nutrients in better availability in root zone coupled with better root activity. Further, it was also due to the reduced loss of these nutrients, particularly under such relatively coarse texture soil under the applied sprinkler irrigation system.

The above-mentioned results are also in harmony with many various benefits of released active organic and humic acids, which have been reported to promote an increase nutrient uptake and stimulate plant growth. However, it promotes plant growth by its effects on ion transfer at the root level by activating the oxidation-reduction state of the plant growth medium and so increased absorption of nutrients, especially micronutrients, by preventing precipitation in the nutrient solution. In addition, it enhances cell permeability, which in turn made for a more rapid entry of nutrients into root cells and so resulted in higher uptake of plant nutrients. This effect was associated with the function of hydroxyls and carboxyls in these compounds as well as the principal physiological function of humic acid may be that they reduce oxygen deficiency in plants, which results in better uptake nutrients **(Humax, 2006)**.

Finally, it is evident from the abovementioned results that application of organic substances such as soaking water extract of organic manure and humic acid achieve many of the beneficial effects on soil hydrophysical properties and fertility status as well as grown plant parameters, since such acids partially capable to retain water and nutrients in soil for grown plants as well as these organic substances acted like plant growth hormones. In addition, it could be interpreted these beneficial reacts of the added active organic substances on the basis that it would act as chelating agent, through OH and COOH as active groups for micronutrients and water molecules, this minimizes the loss of nutrients by leaching. Moreover, such organic substances are considered as a storehouse with easily mobile or available to uptake by plant roots, and in turn reflected positively on development of crop yield and its attributes. These management practices, especially those included liquid fertilizer mixtures should be led to alleviate the harmful effects of excessive soil salinity stress for crop production.

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مقاومة التأثير السلبى لملوحة التربة فى منطقة سهل الطينة على نمو وإنتاجية الذرة الشامية بإستخدام بعض المعالجات السمادية

قدرية مصطفى العزب، أحمد خليل عامر، إبراهيم عبد المنعم حجاب، طارق عبد الرحمن أبو الضيفان
معهد بحوث الأراضى والمياه والبيئة - مركز البحوث الزراعية جيزة - مصر

أجريت تجربة حقلية على تربة طميية رملية تعانى من تأثير الملوحة ونقص فى عنصر الزنك فى منطقة إستصلاح حديثة، قرية جلبانة رقم ٧، سهل الطينة، شمال سيناء، مصر خلال الموسم الصيفى لعام ٢٠٠٩ لتحديد مدى إمكانية استخدام بعض الأساليب العلمية للتغلب على التأثير السلبى لملوحة التربة على مشروعات التنمية الزراعية المستقبلية. وكانت المعاملات التجريبية المستخدمة تتمثل فى صورتين من النتروجين المعدنى هما سمادى اليوريا (٤٦ N٪) وكبريتات الأمونيوم (٢٠.٦ N٪) أضيفا بالمعدل الموصى (١٢٠ كجم N/فدان) كاضافة أرضية، بالإضافة إلى ثلاثة مخاليط من الأسمدة السائلة (١.٠ جم من هيومات البوتاسيوم ٨٥٪ + ٠.٥ جم من كبريتات الزنك مذابة فى لتر من الماء)، (٠.٥ جم من كبريتات الزنك مذابة فى لتر من المستخلص المائى لمنقوع كمبوست الشاى)، (٠.٧٥ حم من كبريتات الزنك مذابة فى لتر من الماء)، حيث أضيفت فى صورة جرعتين متساوتين بمعدل ٣٠٠ لتر/فدان إما رشا على النباتات أو كاضافة أرضية على خطوط النباتات النامية. كما تم زراعة الذرة الشامية – كدليل نباتى – لتحديد مدى إستجابته للنمو تحت ظروف التملح لتربة سهل الطينة، وإنعكاس ذلك على إنتاجيته وجودة حبوبه، وعلاقة ذلك بمدى التحسن المتوقع فى صفات تربة التجربة كنتيجة لتطبيق هذه المعاملات.

وتشير النتائج المتحصل عليها إلى أن تربة التجربة تنتمى إلى الوحدة التقسيمية – حتى مستوى العائلة – إلى "Typic Torriorthents, loamy skeletal, mixed, thermic". كما وأن بعض صفات التربة ممثلة فى حالة الترطيب وقوام التربة والمحتوى من كربونات الكالسيوم والجبس والملوحة/القلوية تعتبر من المحددات الرئيسية لإنتاجية التربة، بدرجة شدة متوسطة لكل من حالة الترطيب وقوام وملوحة/قلوية التربة (٦٥-٧٥٪)، وبسيطة للآخرين (٩٠-٩٥٪). ومن حيث صلاحية التربة للزراعات المروية، وكذا فان تربة التجربة تعتبر هامشية الصلاحية ($S3ws_1n$) بصورتها الحالية، متوسطة الصلاحية عند تحسين مستوى الماء الأرضى وملوحة/قلوية التربة ($S2s_1$). علاوة على أن رتبة صلاحية تربة التجربة للزراعة بنباتات الذرة تعتبر هامشية الصلاحية ($S3ws_1n$) بصورتها الحالية، كما وأن قوام وملوحة/قلوية التربة يعتبرا من أهم محددات إنتاجيتها، وبتحسن مستوى ملوحة/قلوية التربة تتحسن درجة الصلاحية إلى متوسطة الصلاحية، ويظل قوام التربة (s_1) من أهم معوقات الإنتاجية.

وتوضح النتائج أيضا ان القياسات النباتية للذرة ممثلة فى صفات النمو (طول النبات، مساحة الأوراق، ومحتواها من المغذيات)، صفات الكوز (الطول، القطر)، المحصول الحيوى (محصولى الحبوب والقش/فدان)، جودة الحبوب (وزن الـ١٠٠ حبة، البروتين ٪)، الحالة الغذائية للحبوب (المحتوى من عناصر N, P, K, Fe, Mn and Zn) قد سجلت أفضل القيم عند إضافة معدلات سماد كبريتات الأمونيوم مقارنة بنفس المعدلات من سماد اليوريا. بالإضافة إلى أن مخلوط الأسمدة السائلة (٠.٥ جم كبريتات زنك مذابة فى لتر من المستخلص المائى لمنقوع مكمور الشاى) قد تفوق على كلا المخلوطين الآخرين بالنسبة للقياسات النباتية المشار إليها سابقاً. علاوة على أن إضافة مخاليط الأسمدة السائلة كانت أكثر كفاءة بصفة عامة على القياسات النباتية عند رشها كمعاملات أرضية على خطوط النباتات النامية مقارنة بالرش مباشرة على النباتات.

لذا، فان تسميد نباتات الذرة بسماد كبريتات الأمونيوم سوف يشجع من تيسر المغذيات النباتية فى التربة، ويرجع ذلك إلى الدور الفعال لكلا الصورتين الكاتيونية (NH_4^+) و الأنيونية (SO_4^{2-}) المصاحبتين. حيث أن إضافة الصورة الـNH_4^+ أكثر إرتباطا بقدرة التربة على حفظ النتروجين على مدى أوسع عن طريق حفض مخاطر الفقد بالتطاير، الغسيل، عكس النترتة، وكذلك لحفض Soil pH بالنسبة لتأثير أنيونات SO_4^{2-}. وأيضا، فقد وجد أن كلا المستخلص المائى لمنقوع مكمور الشاى وهيومات البوتاسيوم كسماد أرضى سائل لا يمثلا فقط مخزون إستيراتيجى للمغذيات الضرورية للنبات بل أيضا شجعت من إمتصاص المغذيات، قللت من إمتصاص بعض العناصر الضارة بالنبات، دعمت النقص فى عنصر الزنك، أدت إلى تحسن كبير فى حالة التوازن العنصرى فى المحاول الأرضى وكذا كثير من العمليات الفسيولوجية فى النباتات تحت ظروف تملح التربة. وقد إنعكست تلك هذه الظروف الجيدة بصورة إيجابية على قياسات النمو للذرة، محصول الحبوب وبدرجة عالية من الجودة بالنسبة للحالة الغذائية.