Influence of Diluted Sea Water and Foliar Fertilizer on Hydrophysical Properties of a Clayey Soil in Relation to Growth, Yield and Mineral Status of Millet.

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Abstract: A pot experiment was conducted in the greenhouse of the National Research Center, Dokki, Cairo, Egypt to study the effect of irrigation millet plants by diluted sea water and spraying foliar fertilizer (Groue more 16-6-8) on soil physical properties, growth and mineral status. The experiment included 14 treatments: a) soil irrigated by fresh water with and without spraying by foliar fertilizer, b) soil irrigated with 3 levels of diluted sea water 2000, 4000, and 6000 ppm with and without foliar fertilizer and c) soil irrigated with 3 levels of diluted sea water 2000, 4000, and 6000 ppm followed by alternating fresh water with and without foliar fertilizer.

The obtained results showed that Plant height, number and surface area of leaves, stem diameter and fresh and dry weight of plant were decreased by soil salinity compared to that irrigated by fresh water. The depressions were increased with the increment of salts concentration. Spraying foliar fertilizer slightly affected the measured growth criteria of millet plants. The results also indicated that values of soil bulk density were increased by 0.27, 0.65 and 2.15% while that concerning with penetration resistance were increased by 24.0, 27.24 and 32.89 % for 2000, 4000 and 6000 ppm under alternated with fresh water respectively. The relationship between hydraulic conductivity (HC) and sodium adsorption ratio (SAR) showed a general decrease in the values of HC with the increase in SAR. The coefficient of determination, R^2 was 0.991** when saline water alternated with fresh water was used while it was 0.742* under using saline water continuously. On the other hand, increasing soil salinity as a result of using saline water decreased available water of the soil and led also to lowering the uptake of N, P, K, against increasing in Na, Ca and Mg uptake. It is clear that the treatments of alternating diluted sea water with fresh water were better than that used saline water continuously. [New York Science Journal 2010;3(7):1-7]. (ISSN: 1554-0200).

Key words: Millet, salinity, hydraulic conductivity, sodium adsorption ratio.

1. Introduction

Forage crops area and productivity were less than facing the increasing demand of the animal production where the price increases continuously. There are many difficulties against the horizontal expatiation of forage crop as the high competition in cropping systems in the old lands and scarcity of fresh water resources and poor fertility in the new reclaimed areas. Therefore, the searching for nontraditional water resources are needed, such as agriculture drainage water, poor quality underground water, seawater and sewage drainage water and the possibility of use it safely and economically. (Hamdy et al 2005 and Tyagi et al 2005).

The occurred physiological disorders in plants as a result of salinity are particularly in metabolic pathway reflected decreasing in growth and productivity. (Munns 1993, and Batti and Sarwar 1997).

There are several disadvantages when reusing drainage water for irrigation. These include the pesticides, salts, pathogens in soil, deterioration of soil structure, water infiltration, and aeration that results in reduced yield (Rogers, 2001). Nevertheless, many studies in various regions have revealed that saline drainage water can be used without adversely affecting on yield (Bauder and Brock 2001 and Mace and Amrhein 2001).

These investigations have demonstrated that with integrated management of irrigation water of different qualities, it is possible to achieve optimal water use efficiency and to sustain long-term productivity. However, the management strategy should be geared to the quality of the water and soil.

Soil texture is important factor where clays generally compromise the majority of cation exchange sites in soils. This is because clays, by virtue of their small particle size, have the most surface area, and therefore the most exchange sites. Consequently, clay soils have the greatest risk for excess sodium binding and dispersion. (Leal et.al., 2009).

Therefore, this undertaken study aimed to evaluate the effects of irrigation by diluted seawater and spraying foliar fertilizer (Groue more 16-6-8) on soil physical properties, growth and mineral status.

2. Material and Methods

A pot experiment was conducted in the greenhouse of the National Research Center, Dokki, Cairo, Egypt to study the effect of irrigation millet plants by diluted sea water and spraying foliar fertilizer (Groue more 16-6-8) in silty clay soil (7.15% sand, 45.45% silt, and 47.4% clay) on soil physical properties, growth and mineral status. The experimental design was complete randomize blocks in sex replicates. Seeds of millet (***Pennisetum glaucum*** ***L***.) were sown in the 1st. of July 2008. Calcium super phosphate (15.5% P_2 O_5) and Potassium sulphate (48% K_2O) were added before sowing in the rate of 2.29 and 1.14 g/pot respectively. Ammonium sulphate (20.5% N) was applied in the rate of 6.86 g/pot in two equal portions, the 1st, at 20 days after sowing and the other two weeks latter. Application of diluted seawater started from 21days after sowing and stopped after 60 days from sowing

The experiment included 14 treatments as follows:

- Treatments no 1 and 2: soil irrigated by fresh water with and without foliar fertilizer, respectively.
- Treatments no 3 and 4: soil irrigated by diluted sea water 2000 ppm followed by alternating fresh water with and without foliar fertilizer, respectively.
- Treatments no 5 and 6: soil irrigated by diluted sea water 2000 ppm with and without foliar fertilizer, respectively.
- Treatments no 7 and 8: soil irrigated by diluted sea water 4000 ppm followed by alternating fresh water with and without foliar fertilizer, respectively.
- Treatments no 9 and 10: soil irrigated by diluted sea water 4000 ppm with and without foliar fertilizer, respectively.
- Treatments no 11 and 12: soil irrigated by diluted sea water 6000 ppm followed by alternating fresh water with and without foliar fertilizer, respectively.
- Treatments no 13 and 14: soil irrigated by diluted sea water 6000 ppm with and without foliar fertilizer, respectively.

Foliar fertilizer (Groue more 16-6-8) was applied in the rate of 2cm/l twice times, the 1st at 30 days and the 2nd two weeks latter. Two plants from every replicate were taken after 45 days and the following criteria were measured: plant height, number and area of green leaves and fresh and dry weight of stem, leaves, panicle and whole plant. Before harvesting other sample was taken and the following characters were measured: weight of straw, seeds, panicle and whole plant, weight of 100 seeds and length of panicles. Chemical analysis were determined according to the methods described by Cottenie et al., (1982). Bulk density and total porosity were determined according to Dewis and Freitas, 1970, hydraulic conductivity by the constant head method (Klute and Dirksen, 1986), Penetration resistance was measured on dry soil at depth 2.0 cm by a penetrating probe using the equation: $R = (M^2.H)/(M+P).(1/e).(1/s)$. Where: R= resistance ($kg/cm^2$), M=the weight of the hammer (kg), H=the drop distance of hammer (cm), P= weight of the vertical shaft (kg), e=penetration distance for one blow (cm), s= cross- sectional area of the cone (cm2). The M, H, P and s values for the used penetrometer are 0.05kg, 10cm, 0.166kg and 0.156cm^2, respectively. (EL-Hady and Abou Saif 1984). Statistical analysis were done according to the methods described by Snedecor and Cochran (1980).

3. Results and Discussions

1. Vegetative growth:

Significant decrement were obtained in vegetative growth by the increase in salt dose in irrigation water. The fresh and dry weight of whole plant and its response to irrigation by saline water are listed in table (1). The fresh weight of treatments which irrigated by diluted sea water (2000, 4000 and 6000 ppm) followed by alternating fresh water were 75.96, 72.98 and 66.61 g/plant if it compared to that plants irrigated with fresh water (control) 86.09 g/plant while dry weights were 13.89, 13.59 and 12.80 g/plant in comparable with (control) 15.79 g/plant, respectively. Moreover, plants of millet which irrigated by saline water 2000, 4000 and 6000 ppm continuously their fresh weights decreased by 65.59, 62.27 and 50.98 g/plant (86.09 g/plant) while dry weights were 12.41, 12.02 and 10.05 if it compared to control, respectively. In a study on wheat and Faba Bean, El Fouly et al. (2001) indicated that high Na Cl concentrations have negatively effect on dry weight of both plants and the foliar application of micro nutrients could induced increases in tolerance of salinity.

Furthermore, when plants irrigated by 2000, 4000 and 6000 ppm decreased plant height by 39.54, 45.45 and 64.36% and number of leaves/plant decreased by 16.0, 16.0 and 22.0%, however, total leaves area/plant decreased by 34.22, 39.37 and 47.72%, respectively. These data mean that in the case of alternative irrigation by fresh water and saline water some salts precipitate or adsorb on the clay minerals of the soil and affect the cultivated crops, meanwhile, irrigation of millet plants by diluted sea water raised the adverse effect of salts. Also the negative effect increased with the salt concentration increase whereas foliar fertilizer Grouemore did not affect the vegetative growth significantly.

2. Mineral status:

Regardless the effect of diluted sea water on mineral status, data presented in table (2) refer to that subjected millet plants to salt stress lowered the content of N, P, K and protein % and the depression caused from use of 6000 ppm saline water continuously reached to 25.37, 16.67, 29.76 and 25.27% that of irrigated by fresh water, respectively. Meanwhile, the depression decreased to 13.62, 6.59, 17.39 and 13.50 %, respectively when plants irrigated by fresh water alternating with 6000 ppm saline water.

Table (1) Effect of salinity and foliar fertilizer on growth of millet plants.

T	salinity of irrigation water (ppm)		foliar fertilizer	plant height (cm)	number of leaves/plant	Total leaves area cm^2	stem diameter (cm)	Spike length (cm)	Spike weight (g/plant)	fresh weight (g/plant)	dry weight (g/plant)	Straw weight (g/plant)
T_1	294		+	121.00	8.33	1200.10	4.00	19.35	8.14	92.25	16.63	42.21
T_2	294		-	110.00	8.33	1048.50	3.73	18.00	7.91	79.94	14.95	36.58
T_3	2000	294	+	107.00	8.33	1040.75	3.50	17.67	7.08	78.99	14.61	36.14
T_4	2000	294	-	105.83	8.00	855.50	3.33	16.93	5.55	72.94	13.17	33.38
T_5	2000		+	71.00	7.00	739.75	3.00	14.65	1.87	66.20	12.47	30.29
T_6	2000		-	68.67	7.00	739.38	3.00	14.33	1.42	64.97	12.34	29.73
T_7	4000	294	+	106.67	8.00	991.00	3.40	17.17	5.58	75.44	14.22	34.52
T_8	4000	294	-	94.83	7.33	826.88	3.33	16.33	4.13	70.53	12.95	32.27
T_9	4000		+	65.50	7.00	704.25	3.00	14.33	1.19	63.88	12.15	29.23
T_{10}	4000		-	60.50	7.00	659.13	2.83	12.85	1.13	60.66	11.89	27.76
T_{11}	6000	294	+	87.00	7.33	822.00	3.23	15.30	3.58	66.88	12.85	30.60
T_{12}	6000	294	-	85.00	7.33	775.69	3.00	15.15	3.00	66.34	12.74	30.53
T_{13}	6000		+	43.00	6.67	609.88	2.67	11.83	0.82	52.39	10.57	23.97
T_{14}	6000		-	39.33	6.33	565.75	2.47	11.00	0.78	49.57	9.54	22.68
$LSD_{0.05}$				13.65	1.44	241.01	1.265	2.44	2.39	13.92	2.85	6.16

On the other hand, Na, Ca and Mg content increased as salt concentration increase in the water of irrigation. Maximum increment were 300, 88.5 and 50% that of irrigated with fresh water, respectively by using 6000 ppm saline water continuously. These increment were 138.8, 30.1 and 28.1% by applying fresh water alternating with 6000 ppm saline water, in sequence.

These results are in harmony with those obtained by Garg and Gupta (1996) they reported that salinity depressed N, P, and K uptake while Na and Cl contents increased. However, salt tolerant genotype accumulated more K and less Na than salt sensitive genotype. Also Tripathi, et al (1999) found that the total N and P contents in crop plants irrigated with poor quality water (18 and 12.3 dS/m) were lower than those plants receiving comparatively good quality water. Meanwhile, the highest N, P, and K contents and yield was recorded in treatments which received water of EC 4.3 dS/m for pearl millet cultivation or pasture.

Grieve and poss (2000) reported that shoot Ca% of wheat plants increased with the increasing in salinity. Shoots Mg and K decreased significantly in response to increase in salt stress. Salama,et.al., (2000) demonstrated that NaCl caused clear depression in K and Mg and increased Ca and Na content in roots and shoots of maize and soybean.

The spraying of foliar fertilizer slightly increased of N, p, K and protein%. In addition decreased the bad effect for Na slightly. These observation were confirmed with those obtained by Soepardi (1995) who found that application of FOSFGN (high concentrated N and P) increased P concentration in the tissues of Sugar cane.

Table (2) Macronutrients concentration in shoots of millet plants as affected salinity and foliar fertilizer

T	salinity of irrigation water (ppm)		foliar fertilizer	N %	P %	K %	Na %	Ca %	Mg %	Protein %
T_1	294		+	2.69	0.1881	5.89	0.09	0.76	0.63	16.80
T_2	294		-	2.66	0.1801	5.66	0.10	0.79	0.65	16.59
T_3	2000	294	+	2.61	0.1791	5.06	0.13	0.84	0.70	16.28
T_4	2000	294	-	2.58	0.1765	5.03	0.15	0.86	0.71	16.13
T_5	2000		+	2.26	0.1670	4.70	0.24	1.12	0.84	14.11
T_6	2000		-	2.25	0.1635	4.58	0.26	1.16	0.86	14.03
T_7	4000	294	+	2.48	0.1725	4.90	0.16	0.90	0.74	15.50
T_8	4000	294	-	2.44	0.1719	4.80	0.17	0.95	0.76	15.24
T_9	4000		+	2.18	0.1603	4.43	0.29	1.22	0.91	13.66
T_{10}	4000		-	2.16	0.1565	4.40	0.31	1.26	0.93	13.48
T_{11}	6000	294	+	2.34	0.1684	4.79	0.20	0.99	0.80	14.60
T_{12}	6000	294	-	2.29	0.1679	4.76	0.23	1.04	0.84	14.29
T_{13}	6000		+	2.02	0.1515	4.07	0.33	1.44	0.95	12.62
T_{14}	6000		-	1.98	0.1510	4.05	0.38	1.50	0.97	12.34

3. Hydrophysical properties:

Bulk density increases with increase in salt levels in all the cases, whereas particle density and porosity decrease with increase in salt levels. The bulk density of soil is an important field property. It is well known that any factor that influences soil pore space will affect bulk density (Shakir et.al.2002). Soil resistance is an index for soil mechanical strength. In regard to the effect of saline water on bulk density and mechanical strength of soil compared to that irrigated regularly by fresh water, values of bulk density and penetration resistance were increased by 0.27 and 24.0%; 0.65 and 27.24%; and 2.15 and 32.89% that of control by using fresh water alternating with saline water 2000, 4000, 6000ppm, respectively. Continued use of water having a high SAR leads to a breakdown in the physical structure of the soil. Sodium is adsorbed and becomes attached to soil particles. The soil then becomes hard and compact when dry and increasingly impervious to water penetration. Fine textured soils, especially those high in clay, are most subject to this action. When the soil was irrigate with 2000, 4000, and 6000ppm continuously, the corresponding increments were 3.68 and 46.86%; 5.72 and 71.34%; and 7.64 and 89.68%, in sequence.

On the other hand, Values of void ratio, total porosity and hydraulic conductivity took an opposite trend to that of bulk density and penetration resistance. Decrements in the above three mentioned parameters relative to those of control soil amounted to 6.97, 3.56 and 21.67%; 10.64, 5.53 and 38.33% and 13.93, 7.39 and 65.0% when the soil irrigated with 2000, 4000 and 6000ppm saline water continuously, respectively. Meanwhile, the hazard effect for this soil decreased when using fresh water alternating with saline water. Thus decrements were only 0.48% for the void ratio; 0.26% for total porosity; and 3.33% for hydraulic conductivity when using irrigation water with low dose of salts (2000ppm). While these values depressed to be 1.26,.63 and 8.33%; and 4.16, 2.08 and 11.67% that of control soil by applying fresh water alternating with 4000; 6000ppm salinity water, respectively. These results are confirmed with those obtained by Shakir et.al.(2002). Salt accumulation in the root zone decreased as the leaching fraction increased.

Table (3) Physical properties of soil treatments.

T	salinity of irrigation water (ppm)		foliar fertilizer	Bulk density g/cm3	total porosity %	Hydraulic Conductivity cm/hr	void ratio	penetration resistance kg/cm2	available water %
T_1	294		+	1.302	50.87	0.60	1.035	20.80	18.14
T_2	294		-	1.304	50.79	0.60	1.032	20.79	18.11
T_3	2000	294	+	1.307	50.68	0.58	1.028	25.77	17.84
T_4	2000	294	-	1.306	50.72	0.58	1.029	25.79	17.81
T_5	2000		+	1.350	49.06	0.47	0.963	30.55	17.02
T_6	2000		-	1.352	48.98	0.47	0.960	30.53	16.99
T_7	4000	294	+	1.312	50.49	0.55	1.020	26.45	17.36
T_8	4000	294	-	1.311	50.53	0.55	1.021	26.47	17.35
T_9	4000		+	1.377	48.04	0.37	0.924	35.64	16.72
T_{10}	4000		-	1.378	48.00	0.37	0.923	35.62	16.69
T_{11}	6000	294	+	1.332	49.74	0.53	0.989	27.64	17.31
T_{12}	6000	294	-	1.330	49.81	0.53	0.992	27.63	17.31
T_{13}	6000		+	1.403	47.06	0.21	0.889	39.44	15.69
T_{14}	6000		-	1.402	47.09	0.21	0.890	39.45	15.60

Aggregate stability and infiltration properties of the soil were generally adversely affected by the more saline and sodic irrigation waters. Thus the maximum dispersion was observed in T13 & T14 (irrigated with 6000ppm continuously). Clays generally compromise the majority of cation exchange sites in soils. This is because clays, by virtue of their small particle size, have the most surface area, and therefore the most exchange sites. Consequently, clay soils have the greatest risk for excess sodium binding and dispersion. (Leal et.al., 2009). The presence of clays and specific clay types will generally exacerbate dispersion problems. Soil properties associated with dispersion include bulk density (Curtin et al., 1994_a), percent clay-size particles (Morshedi, and Sameni. 2000), pH (saturated paste extract) (Curtin et al., 1994_b), electrical conductivity (EC) (saturated paste extract) (Curtin et al., 1995), sodium adsorption ratio (SAR) (Curtin et al., 1994_a).

Increasing soil solution salinity will decrease available water. This will have a negative effect on crop yield and may affect survival, if salinity levels are high enough. This finding may be the result of soil solution salinity restricting availability of water to the millet plants by lowering the total water potential in the soil (FAO, 1992). These decreases were calculated to be 1.63% that of control soil for T3 & T4 when using fresh water alternating with saline water 2000ppm. While it decreased by 6.15, 7.81, and 13.66% that of control soil when applying saline soil 2000, 4000, 6000ppm, respectively. The same trends slightly were 4.2 and 4.5% that of control soil when applying fresh water alternating with saline water 4000 and 6000ppm, in sequence. This result is agreeable with those obtained by Bauder and Brock, (2001).

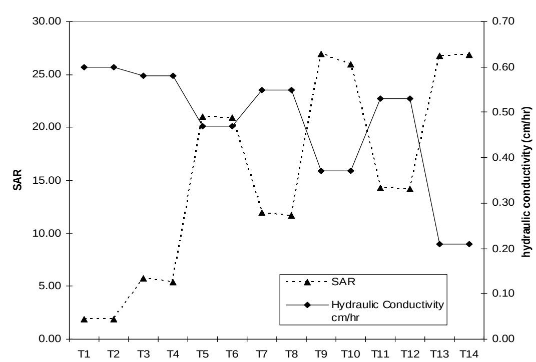
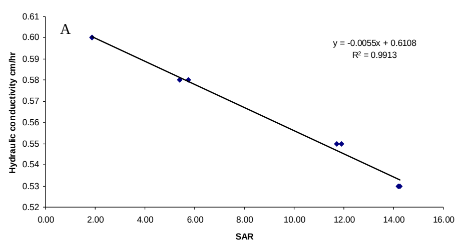


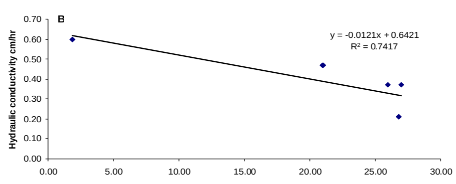
Figure 1: Effect of saline water on hydraulic conductivity and sodium adsorption ratio.

Exchangeable sodium percentage (ESP) and electrolyte concentration of the soil solution play a significant role in determining soil physical properties and the response of soil clays to dispersion and swelling. (Levy et.al. 2003). Thus, reduced permeability and hydraulic conductivity due to sodicity compound this problem. Therefore, the decrease in hydraulic conductivity may be attributed to the increase in SAR that accompanied the increase in salt concentration (Table 3 and Fig.1).

The relations between SAR and hydraulic conductivity at different salinity levels are illustrated in Fig.1 and 2. The hydraulic conductivity values show a general decrease as SAR increase. The linear regression analysis was used in an attempt to describe the relation between the SAR and the hydraulic conductivity. Results of the analysis are shown in Fig.2. The coefficient of determination, R^2 was 0.742 and 0.991 being significant at 0.05 and highly significant at 0.01 and represent this relation the following equations: y = -0.0121x + 0.6421 and y = -0.0055x + 0.6108 when using saline water continuously and by using fresh water alternating with saline water, respectively. Where: y= hydraulic conductivity in cm/hr and x= SAR. This means that a negative correlation between SAR and hydraulic conductivity



Fig(2) Effect of sodium adsorption ratio on hydraulic conductivity under soil irrigated with A) saline water followed by alternating fresh water, B) saline water continously



These results are in agreement with those of (Tayel et.al., 1980 and Shainberg and Letey, 1984). The data demonstrate that hydraulic conductivity decreases quite rapidly as SAR increases. The SAR at which the conductivity diminishes depends on the EC of the applied water, although the rate of decrease is approximately the same as sodium levels in the irrigation water increase. These results are in accordance with those obtained by (Shainberg and Letey, 1984). This dispersion, in turn, leads to a reduction in soil hydraulic conductivity.

4. Conclusion:

Although, the negative soil physics effects for all cases, the soil physical properties are still acceptable exception which irrigated with 6000ppm continuously, tend to more dispersion, sodium excess and poor physical properties. The cumulative effects of long-term supplemental irrigation with saline-sodic waters on soil chemical and physical properties need to be considered when assessing irrigation water suitability.

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5/6/2010