Soil Science (Group Kemet)

Wheat Response to Nitrogen and Zinc Fertilization under Saline Condition in Calcareous Soil

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Abstract

A pot experiment was carried out to study the effect of nitrogen and zinc fertilization on the growth, nutrient uptake and yield of two wheat cultivars (Sakha 8 and Sakha 69) grown under saline water irrigation in calcareous soil. Nitrogen, as ammonium sulphate and ammonium nitrate, was applied at rate of 100 kg N/fed. Zinc was applied as zinc sulphate at rates of 0.0 and 5 kg/fed. Three salinity levels (EC 0.62; Nile water as control, wells water have 7.8 and 15.6 dSm^{-1}) were applied.

Nitrogen and zinc fertilization enhanced the dry matter and grain yield of plants. However, ammonium sulphate was more effective than ammonium nitrate. N, P, K and Zn uptake in shoots and grains were increased by N and Zn fertilizers addition. Increasing salinity from EC 7.6 to 15.8 reduced the dry matter yield, grain yield and N uptake. Meanwhile, the Na concentration in shoots was increased. Sakha 8 was more effective than Sakha 69 for grain yield, minerals uptake. The cultivar Sakha 8 is more salt tolerant than Sakha 69.

Introduction

Wheat is one of the most important field crops for human food. Thus intensive efforts have been performed to increase its production by several agricultural means. One of these means is the use of N-fertilization (EL-KOUMEY and EL-SHAFIE, 1997).

Competition among all sectors of society for good-quality water has focused a great attention on the use of the poor-quality waters in agriculture (DEVITT et al., 1987). However, if saline or waste water is used, attention must be given to assess the impact of such water on productivity. Low quality of irrigation water, such as well water, has been used in some Egyptian areas for irrigation, whenever, the Nile water was not available. These areas may be subjected to salt accumulation. The potential of crop productivity under such conditions is depending on the plant response to osmotic stress and on the relative toxicity of some ions such as Na^+ and Cl^- (MARSCHNER, 1995). In most cases, a reduction in the yield was normally associated with an accumulation of soluble salts in plant tissues (MENGEL and KIRKBY, 1987).

Nitrate and ammonium ions constitute the most important nitrogen forms taken up by plants. Moreover, in many arable soils where nitrification normally takes place rapidly, nitrate and ammonium are the prominent sources (EL-SHINNAWI et al., 1988).
Since zinc is very closely involved in the N metabolism within plant tissues, foliar spray of wheat plants with Zn under certain soil conditions such as high pH, in arid and semi-arid regions, had been found to have a positive effect on its growth and yield. This enhancing effect may be due to the high degree of nutrient utilization in plant tissues (DORING and GERIKE, 1985).
This work is an attempt to spot a light on the effect of two N forms (nitrate & ammonium) and Zn fertilization on the growth, nutrient uptake and yield of two wheat cultivars grown under saline conditions in calcareous soil.

Materials and Methods

Surface (0 – 30 cm) calcareous soil samples were collected from the Experimental Farm of the soil salinity laboratory, Agric. Res. Center, Alexandria, Egypt. Soil samples were air dried and ground to pass through a 2 mm sieve. Physical and chemical properties of the used soil were determined according to BLACK (1982) as shown in Table (1 a).

Table 1 a: Some physical and chemical characteristics of the experimental soil.

Property	Value	Property	Value
Physical characteristics:		Soluble ions (meq 100 g^{-1}):	
Sand, %	81	Ca^{2+}	1.66
Silt, %	10	Mg^{2+}	2.87
Clay, %	9	Na^{+}	7.29
Texture class	Loamy sand	K^{+}	3.30
Chemical characteristics:		HCO_3^-	1.06
OM, %	0.40	Cl^-	11.66
pH (1 : 2.5 soil / water sus.)	7.30	$SO_4^=$	2.40
EC, dS m^{-1}	1.08	Total N, %	0.09
$CaCO_3$ %	33.14	Available P μg g^{-1}	16.0
SAR	4.95	Zn μg g^{-1}	1.80
ESP	4.52	Fe μg g^{-1}	3.20
		Mn μg g^{-1}	4.10

Glazed pots, (30 cm diameter and 25 cm depth) were filled with 12 kg air dried soil. Twenty grains of wheat (*Triticum aesativum* L., Sakha 8 and Sakha 69 cvs.) were sown and 20 days later, the seedlings were thinned to 10 per pot. The pots were arranged in a complete randomized block design with four replicates. The other agriculture practices were applied as recommended for wheat production in Egypt. Three salinity levels were used Nile water with EC 0.62 dSm^{-1} as a control, ground water wells with 7.8, and 15.6 dSm^{-1} in the Soil Salinity Laboratory at Abis, Alexandria Governorate. Water characteristics are tabulated in Table (1 b).
Two nitrogen forms, ammonium nitrate and ammonium sulphate were added to the soil at the rate of 100 kg N/feddan, corresponding to 3.6 and 5.7 g N/pot, respectively. N fertilizer was added in two equal portions, before the first and the second irrigation. Zinc sulphate was applied as foliar application at two rates 0 and 5 kg / fed. Foliage spray of Zn was applied at 35 days from sowing. Plant samples were taken during the

growth period (at 45, 90 and 120 days from sowing), washed, air dried. The plant materials were divided into two parts, one dried at 70°C (24 hrs) for chemical analysis and the another at 105°C for dry weight determination. Samples were thoroughly ground and ashed by wet digestion according to JACKSON (1967). Total N was determined using micro-kjeldahl method after JACKSON (1967). P, K and Na were determined by flame fotometer as described by CHAPMAN and PRATT (1961). Available Fe, Zn and Mn in wheat shoots were determined using the atomic absorption spectrometer (Model Phillips Pu 9100).

At harvest time, the number and weight of spikes / pot, weight of 100 grains, grains weight (g/pot) were determined. N, P, K and Zn in grains were determined according to CHAPMANN and PRATT (1961). Grain crude protein content was calculated by multiplying N values by the conversion factor 6.25. All data were statistically analyzed according to GOMEZ and GOMEZ (1983).

Table 1 – b: Chemical characteristics of irrigation water samples.

Property	Irrigation water dSm^{-1}		
	EC 0.62	**EC 7.8**	**EC 15.6**
pH	7.9	7.7	7.6
SAR	1.96	21.10	28.40
Soluble ions mg L^{-1}:			
Ca^{++}	2.20	6.45	20.19
Mg^{++}	1.73	10.92	23.90
Na^{+}	2.75	62.21	133.50
K^{+}	0.18	3.90	6.31
HCO_3^{-}	3.55	2.90	4.35
Cl^{-}	2.11	59.47	125.37
$SO_4^{=}$	1.20	21.11	54.8

Results and Discussion

3.1. Dry matter yield

Data in Table (2) revealed that the dry matter yield of wheat shoots increased gradually to reach a maximum value at 90 days from sowing, then tended to decrease. This decrease may be due to stopping the development of new leaves and / or leaf shedding in the late stages of growth. Moreover, the migration of minerals from leaves to grains may share the decrease in dry matter yield at late stage. Data in Table (2) indicated also that ammonium sulphate was more effective in increasing dry matter yield than ammonium nitrate. This enhancing effect of ammonium sulphate is probably due to its content from sulpher which is an essential nutrient element. Sulpher also may improve the soil pH since its solution has an acidic effect. Similar results were obtained by EL-SHINNAWI et al. (1988) EL-MOATASEM et al. (1993).

Zinc fertilizer showed an enhancing effect on the dry matter yield of wheat at both nitrogen forms. This results may be due to the role of Zn as a co-factor in the enzymatic reactions of the anabolic pathways in plant growth. These results are parallel to those obtained by EL-HABBAL et al. (1995) and EL-KOUMEY and EL-SHAFIE (1997).

Sakha 8 variety showed a superiority on Sakha 69 in its tolerance to salinization. The dry matter yield was not affected by the (EC 7.8) and slightly affected by the irrigation with the high level of salinity (EC 15.6). The higher level of saline water showed a depressing effect on dry matter yield of wheat plants. This effect may be attributed to the high osmotic pressure of the soil solution which induces a detrimental effect on the nutrient absorption by plants, consequently impairing the growth of wheat crops (MARSCHNER, 1995). This results are in accordance with those obtained by FRANCOIS et al. (1986), NOUR et al. (1990) and EL-HADDAD et al. (1993).

Macronutrients

Nitrogen

Data in Table (3) revealed that ammonium sulphate surpassed ammonium nitrate in increasing the concentration and uptake of nitrogen by both cultivars of wheat. This may be ascribed either to genetical properties of wheat plants which have a preference for taking up ammonium nitrogen, or to the enhancing effect of ammonium sulphate on the availability of nutrients in the soils consequently stimulating the plant growth and their capability to take up more nitrogen from the soil (MENGEL and KIRKBY, 1987). Zinc application with the both nitrogen forms showed a beneficial effect on enhancing the N-uptake of wheat plants. This may be due to the important role of Zn in plant growth. These results go along with those of EL-BASIONI et al. (1993).

Table 2: Dry weight of wheat shoots (g/pot) as affected by saline water, N and Zn fertilization at different growth stages.

Treatments	**Salinity levels dSm^{-1}** **EC 0.62 (control)** 45 DAS	90 DAS	120 DAS	**EC 7.8** 45 DAS	90 DAS	120 DAS	**EC 15.6** 45 DAS	90 DAS	120 DAS
	Sakha 8								
$Zn_0 + N_4H\ NO_3$	59.0	91.0	51.0	62.0	96.0	47.0	49.0	86.0	34.0
$Zn_1 + N_4H\ NO_3$	68.0	97.0	57.0	67.0	99.0	55.0	57.0	95.0	37.0
$Zn_0 + (N_4H)_2\ SO_4$	67.0	104.0	56.0	66.0	105.0	57.0	53.0	91.0	40.0
$Zn_1 + (N_4H)_2\ SO_4$	75.0	113.0	69.0	75.0	115.0	66.0	61.0	102.0	48.0
Mean	68.0	101.0	58.0	68.0	104.0	56.0	55.0	94.0	40.0
	Sakha 69								
$Zn_0 + N_4H\ NO_3$	54.0	84.0	43.0	42.0	73.0	39.0	32.0	46.0	28.0
$Zn_1 + N_4H\ NO_3$	59.0	90.0	59.0	45.0	79.0	56.0	39.0	51.0	28.0
$Zn_0 + (N_4H)_2\ SO_4$	59.0	93.0	53.0	50.0	79.0	49.0	34.0	57.0	31.0
$Zn_1 + (N_4H)_2\ SO_4$	68.0	96.0	69.0	53.0	85.0	59.0	44.0	64.0	30.0
Mean	60.0	91.0	56.0	48.0	79.0	51.0	37.0	55.0	29.0

			45 DAS	90 DAS	120 DAS		DAS	Days after sowing
LSD	(A)	5%	4.4	4.0	6.0		(A)	Fertilizers
	(B)		3.7	3.0	5.0		(B)	Salinity
	(C)		3.0	3.0	4.0		(C)	Variety

Salinity at high level decreased N uptake by wheat plants. The average reductions of N uptake were 23 and 92% for Sakha 8 and Sakha 69, respectively. This decrease in the nitrogen uptake may reflect the inhibiting effect of the high salinity on the dry matter yield of plant shoots.

Phosphorus

Data presented in Table (3)[8] showed that ammonium sulphate increased phosphorus concentration and uptake by wheat plant more than ammonium nitrate. This increase may be attributed to the acidic effect of ammonium sulphate added to the calcareous soil on elevating the availability of phosphorus in soil and consequently increasing its uptake by plants. Similar results in confidence with these findings are reported by MOSTAFA and HASSAN (1995). In this connection, SOON and MILLER (1977) found that the ammonium–fed plants usually have higher phosphorus contents in the shoots than nitrate–fed plants.

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[8] Tables 3-6 are only available in the print copy (Beihefte zu Der Tropenlandwirt Nr. 71)

Phosphorus uptake by wheat plants greatly increased by zinc application with both nitrogen forms, however, the increase with $(NH_4)_2$ SO_4 tremendously excelled that one occurred by NH_4 NO_3 addition. These results obviously revealed the beneficial effect of zinc application to calcareous soil on stimulating the capability of wheat varieties to uptake more phosphorus, particularly under ammonium sulphate fertilization.
The same data elucidated also that the phosphorus concentration in wheat plants was slightly affected by salinity levels, however the P uptake was affected by the highest salt concentration of the applied water in Sakha 69. These results are in agreement with those obtained by MASHHADY et al. (1982), SOLIMAN et al. (1994), MOSTAFA and HASSAN (1995) and MASHEN (1996).

Potassium

Results in Table (3) show in most cases that application of N in different sources caused significant effects on K uptake. Furthermore, data reveal that addition of $(N_4H)_2SO_4$ recorded higher amounts of K contents than those obtained by using N_4HNO_3. Application of zinc fertilizer showed a marked increase in potassium concentration and uptake. This may be due to the beneficial effect of applied zinc. The high salinity level showed a significant decrease in dry matter yield of plant shoots, which has been reflected on the potassium uptake (Table 3). Similar results are reported by CHIPA and LAL (1986) and SHARMA (1996).

Sodium

The data in Table (3) showed that irrigation of the wheat plants by saline water vigorously raised Na^+ concentration and uptake in comparison with the plants irrigated with the Nile water. This is referred to the remarkable diffusion and mass flow from the higher concentration gradient (Na^+) of the saline soil solution to plant roots, consequently, plant tops. Similar results were obtained by REGGIANI et al. (1995), SHARMA (1996).
Zn application increased Na^+ concentration and uptake by wheat plants. The enhancing effect of zinc was more obvious under salinization if compared with non-saline condition. This may be due to the role of zinc in raising the ability of plant to uptake more nutrients under salinization.

Micronutrients

With respect to the concentrations of Fe, Zn and Mn in wheat shoots, Table (4) showed that increasing the salinization alleviated the antagonistic effect between Zn and Fe. At the highest salinity level of the irrigation water, Zn application, particularly with Sakha 69, tended to enhanced rather than inhibited the Fe concentration and uptake by wheat plants. It is evident that ammonium sulphate influenced the concentration and consequently the uptake of Fe in treated plant tissues than ammonium nitrate as shown in the same table. Similar results were obtained by MENGEL and KIRKBY (1987) and IBRAHIM and SHALABY (1994).
The data in Table (4) showed no significant differences between ammonium sulphate and ammonium nitrate in their effect on Zn concentration and uptake by wheat plants. The same data explicated that the application of Zn enormously increased Zn concentration and uptake by wheat plants. Zn uptake by Sakha 69 was found to be more significantly decreased by salinity than Sakha 8, this reflects the depressive effect of salinity on dry matter yield of wheat plants and consequently, its nutrients uptake. These results are in a harmony with those reported by SALLAM (1992) and MOHAMED (1994).
Regarding the Mn contents in Zn-untreated wheat plants, data showed an increase in Mn concentration than those treated with Zn. The depressive effect of Zn on Mn con-

centration and uptake may be attributed to the antagonistic effect of high Zn application on Mn concentration and uptake. This antagonism may be attributed to the competition for binding sites in the roots during the uptake process (MARSCHNER, 1995). The same antagonistic effect of Zn on Mn was appeared also under salinity condition, although the highest level of saline water apparently reduced this effect. In contrast with the above mentioned results, ammonium nitrate surpassed ammonium sulphate in its enhancing effect on Mn concentration in wheat shoots. This results were confirmative to those of MENGEL and KIRKBY (1987).

Yield and its components

Data in Table (5) showed that N and Zn fertilization significantly increased grain yield per pot, weight of 100 grains, number of spikes/pot and spikes weight (g/pot) of both cultivars of wheat plants.

The salt tolerant cultivar (Sakha 8) had a higher grain-yield of wheat plants than the susceptible one (Sakha 69). Data recorded in Table (5) indicated that the reduction in grain yield per pot at higher salinity level was lower in Sakha 8 than in Sakha 69. With regard to nitrogen forms, the ammonium sulphate was more effective in increasing grain yield per pot than ammonium nitrate. This positive effect of ammonium sulphate is probably due to its content of sulpher which is an essential nutrient element. Similar results were obtained by MOSTAFA and HASSAN (1995) and BOTELLA et al. (1997).

Data presented in Table (5) showed that Zn application significantly increased the grain yield per pot and yield components of wheat plants. This may be due to the important role of Zn for the activation of various types of enzymes, such as those required for the CO_2 assimilation pathway (MARSCHNER, 1995).

The negative effects of salinity on the yield and its components in Sakha 69 was more sensitive to salinity than Sakha 8. The inhibition in growth of wheat plants is due to high salt concentration in the soil solution (i.e. high osmotic pressure and consequently low soil water potential) and high concentration of potentially toxic ions such as Cl^- and Na^+ which might lead to ion toxicity and nutritional imbalance, consequently growth inhibition (MARSCHNER, 1995). Similar results were obtained by IELAND et al. (1994) and SOLIMAN et al. (1994).

Yield quality

The data in Table (6) indicated that ammonium sulphate excelled ammonium nitrate in their effect on increasing N, protein, P, K and Zn percentages in the wheat grains. This may be attributed to the acidic effect of ammonium sulphate added to the calcareous soil on elevating the availability of P in soil and consequently increasing its uptake by wheat plants. Foliar application of Zn significantly stimulated N, protein, P, K and Zn concentrations in grains. This may be due to the important role of Zn for protein synthesis (MENGEL and KIRKBY, 1987).

Table (6) showed decrease in nitrogen content and increase in P, K and Zn percentages due to increasing salinity levels. The cultivar Sakha 8 showed more accumulation of N, P, K, Zn and protein contents of grains than Sakha 69. These results are in a harmony with those obtained by DEVITT et al. (1987).

Finally, it can be concluded from our results that the application of ammonium sulphate and zinc sulphate showed a beneficial effect on increasing growth, nutrient uptake and grain yield of wheat plants. On the other hand, Sakha 8 was found to be more tolerant to salinization than Sakha 69.

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Effect of Balanced Fertilization and Ploughing Depth on Elemental Composition of Sugar Beet and some Chemical Properties in Salt Affected Soils

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Abstract

Two field experiments were carried out during two successive seasons at the experimental farm of Faculty of Agriculture, Kafr El-Sheikh to study the interaction effect of balanced fertilization with NPK (N-rates: 0, 72, 144 and 216 kg N/ha, P-rates: 0, 36 and 72 kg P_2O_5/ha and K-rates: 0, 36, 72 and 108 kg K_2O/ha) and soil ploughing depth (shallow at 15 cm and deep at 30 cm) on some soil properties and uptake of NPK by sugar beet plant (cultivar, Maribo Poli). The soil used had clay texture, 86 meq/L of total soluble salts and belongs to soil order of vertisol.

The results of plant analysis indicated that, NPK concentration were increased in shoots of sugar beet plant under deep ploughing compared with shallow one. The highest value of N concentration was obtained at 216 kg N/ha of N application whereas the highest value of P and K concentration were recorded at 72 kg P_2O_5/ha and 72 kg K_2O/ha, respectively.

Soil analysis after sugar beet harvesting showed that, soil pH and total soluble salts were decreased under deep ploughing (30 cm depth) without any addition of fertilizers. On the other side, addition of NK fertilizers haven't significant decrease on soil pH but superphosphate fertilizer had partial effect on decreasing soil pH in the surface soil layer (0-15 cm). Statistical analysis showed that the relationship between NPK fertilizers and ploughing depths was highly significant in decreasing the electrical conductivity of soil solution.

The calculated values of sodium adsorption ratio (SAR) from soluble Ca^{+}, Mg^{++} and Na^{+} measured in soil solution after harvesting of sugar beet plants and hence exchangeable sodium percentage (ESP) were decreased in the soil surface (0-15 cm) under deep ploughing at 30 cm compared to shallow ploughing at 15 cm. On the other side, the lowest value of SAR (2.27) and ESP (4.44%) were obtained under deep ploughing and addition of 72 kg N/ha, 72 kg P_2O_5/ha and 36 kg K_2O/ha of added fertilizers.

Introduction

Sugar beet has become one of the major winter field crop in Egypt due to its high income to the farmers. Its area tended to increase year after another especially in salt affected soils. Fertilization is one of the most important limiting factor for sugar beet production under Egyptian conditions. Complete and balanced fertilization of NPK is important for high crop production.

Ploughing is one of the main practices operated before sugar beet planting which used to provide the necessary soil conditions favorable to growth of that crop. Agboola (1981) showed that tillage and fertilizers application reduced the organic matter content, soil pH, and slightly increased exchangeable potassium and phosphorus. Rezk *et al*. (1982) found that, tillage operation had a general depressive effect on the EC of the surface of soil.

Many investigators reported that nitrogen is the most limiting nutrient for sugar beet (Kemp *et al.,* 1994, El-Attar *et al.,* 1995 and Rezk *et al.,* 1995). Other researchers concluded that application of phosphorus affected the yield and quality of sugar beet (Abbott and Nelson, 1983, Hegazy *et al.,* 1992 and Abou El-Soud *et al.,* 1994). On the other side, sugar beet plant has an affinity to potassium element, Mittchera (1978) and Ghaly *et al*. (1984) reported that increasing K fertilization rate resulted in increasing K content and sugar root yield.

Therefore, the objective of this research was to investigate the interaction effect between soil ploughing depth and NPK fertilization on some chemical properties of salt affected soil and nutrients uptake by sugar beet plants.

Materials and Methods

A field experiment was conducted at the experimental farm of the Faculty of Agriculture, Kafr El-Sheikh, Tanta Univ., during two successive seasons. Some soil properties of the soil used are shown in Table (1) which had clay texture (50% clay) and belongs to vertisol order.

The experiments were carried out in split plot design with three replicates. The main treatments were ploughing depth (15 and 30 cm), while the subtreatments were different rates of NPK fertilizers. Nitrogen was added in the form of urea (46% N) at four rates of application (0, 72, 144 and 216 kg N/ha). Every rate was added in three equal portions after thinning and before the second and the third irrigation. Potassium sulphate (48% K_2O) was added at four rates of application (0, 36, 72 and 108 kg K_2O/ha). Each rate was applied in two equal portions, after thinning and before the second irrigation. Superphosphate fertilizer (15.5% P_2O_5) was added before planting at three rates of application (0, 36 and 72 kg P_2O_5/ha).

Table (1): Mean values of some chemical properties of the studied soil before planting

Soil characteristics	Soil depth, 0-15 cm
Electrical conductivity, dS/m (paste)	8.56
pH (1: 2.5 soil/water ratio)	8.85
Soluble cations, meq/L (paste):	
Ca^{++}	18.00
Mg^{++}	23.00
Na^{+}	42.00
K^{+}	2.00
Total carbonate (%)	3.42
Sodium adsorption ratio (SAR)	9.3
Exchangeable sodium percentage (ESP), %	11.12
Total nitrogen (%)	0.20
Available-P, $NaHCO_3$-extractable P (mg/kg)	12.08
Available-K, NH_4OAC-extractable K (mg/100 g)	21.84

Sugar beet cultivar (Maribo Marina Poli) was sown on November and harvested at the end of May (about 200 days). All agricultural practices were carried out according to conventional local recommendation of the Ministry of Agriculture, Egypt.

Plant samples (leaves) were collected from each plot at the end of every season. Each sample was washed with distilled water and dried in oven at 70°C. Wet digestion was used in H_2SO_4-H_2O_2 mixture to determine the concentration of the three major elements (NPK) according to Chapman and Pratt (1961).

After harvesting, soil samples were taken at 0-15 cm depth, dried and prepared for chemical analysis. The electrical conductivity (EC) and water soluble cations (Ca^{++}, Mg^{++} and Na) were determined in the soil water ratio at 1: 5 according to Page *et al.,* 1982. SAR and ESP were calculated from values of soluble cations according to the following equations:

$$\text{SAR} = \frac{\text{Na}^{+}}{\sqrt{(\text{Ca}^{++} + \text{Mg}^{++})/2}} \text{ \& ESP} = \frac{\text{ESR}}{1+\text{ESR}} \text{ x 100 (Black, 1983).}$$

Where: ESR = -0.0126 + 0.01475 SAR

Soil reaction (pH) was measured in soil suspension (1: 2.5 soil/water ratio). Data were statistically analyzed according to Snedecor and Cochran (1980) using multiple range test at 5% and 1% levels.

Results and Discussion

Root yield of sugar beet crop:

Data presented in the first part of this work by the same authors (Khalifa *et al.,* 2000) showed that, addition of 216 kg N/ha + 72 kg P_2O_5/ha + 108 kg K_2O/ha were considered the most suitable needs from nutrients for sugar beet plants under deep ploughing (30 cm). The general mean of roots yield was about 96 and 89 ton/ha for different NPK treatments under deep and shallow ploughing, respectively. The corresponding values were 26 and 21 ton/ha without any addition of fertilizers. Whereas mean values of the sucrose percentage were found to be 16.5 and 15.1% at different treatments of NPK under shallow and deep ploughing, respectively. The corresponding values were 12 and 11% without any addition of fertilizers. That means, deep ploughing may be encouraged the roots of sugar beet to penetrate and move through the soil and getting the best of their nutritive needs from the soil.

N, P and K concentration in shoots of sugar beet plant:

Table (2) indicated that N concentration was increased in shoots of sugar beet plant under deep ploughing compared with shallow one, where N concentration was 2.98% and 2.24% without any addition of fertilizers, respectively. Application of N increased N concentration in shoots of sugar beet up to 5.32% under deep ploughing and 216 kg N/ha. Addition of P fertilizer encouraged nitrogen uptake by sugar beet plants, where the highest value of N concentration was obtained under the second level of P (72 kg P_2O_5/ha). This may be due to that, the deep ploughing facilitated the root distribution, and consequently increased the absorption area of plants to nutrients. On the other hand, data showed that increasing of added potassium had no effect on concentration of N in shoots, where the highest value of N concentration was obtained at N_{216} P_{72} K_0 for both shallow and deep ploughing.

The results showed that, also phosphorus content in sugar beet was higher under deep ploughing than shallow one. The highest value of P concentration was 5.75 mg P/g dry matter of plant under deep ploughing and $N_{144}P_{72}K_{72}$ treatment. This result indicated that, higher dose of added-N (216 kg N/ha) may be increasing the vegetative growth and decreasing phosphorus absorption by plants. On the other hand, potassium absorption by sugar beet plants was increased with increasing added K up to 108 kg K_2O/ha under different treatments of other nutrients (N and P), but the concentration of K in plant shoots was higher under deep ploughing than its under shallow one. Maximum concentration of K in the shoots was obtained at $N_{72}P_{36}K_{108}$ of added fertilizers under deep ploughing. These results indicated that deep ploughing lowered fertilizer requirements and gave the best uptake at balanced fertilization. This was in agreement with the studies of Bajpai and Joshi (1992) and Hamissa (1995).

Table (2): Concentration of N, P and K in sugar beet plant (shoots) as affected by soil ploughing depth and increment rates of NPK fertilizers.

Fertilizer treatments		Shallow ploughing at 15 cm			Deep ploughing at 30 cm	
	N %	P mg/g plant	K mg/g plant	N %	P mg/g plant	K mg/g plant
$N_0P_0K_0$	2.24	2.12	21.45	2.98	2.87	36.27
$N_{72}P_{36}$ K_0	2.24	2.20	36.27	3.40	2.97	42.12
K_{36}	3.19	2.29	37.05	4.05	4.16	65.52
K_{72}	2.87	2.94	42.12	4.69	3.77	72.15
K_{108}	3.62	2.47	44.85	3.83	3.30	76.05
Mean	2.98	2.48	40.07	3.99	3.54	63.96
$N_{144}P_{36}$ K_0	2.66	2.88	38.22	3.51	3.48	42.90
K_{36}	3.30	2.14	40.17	3.51	3.22	50.70
K_{72}	3.41	3.10	50.70	3.73	4.60	58.50
K_{108}	3.09	2.87	57.72	3.41	3.43	59.67
Mean	3.12	2.75	46.70	3.54	3.68	52.94
$N_{216}P_{36}$ K_0	4.04	3.27	40.95	4.36	3.72	49.92
K_{36}	4.15	2.21	42.90	4.26	3.43	53.82
K_{72}	3.30	2.67	47.97	3.73	3.60	68.25
K_{108}	2.34	2.53	66.30	4.05	3.02	70.20
Mean	3.46	2.67	49.53	4.10	3.44	60.55
$N_{72}P_{72}$ K_0	2.56	2.34	37.05	4.15	4.06	48.75
K_{36}	3.09	2.46	47.97	3.51	4.80	51.87
K_{72}	3.19	4.04	53.82	4.15	5.48	60.45
K_{108}	2.56	3.87	54.60	3.83	4.13	64.35
Mean	2.85	3.30	48.36	3.91	4.62	56.36
$N_{144}P_{72}$ K_0	2.77	3.64	40.17	4.26	4.36	49.92
K_{36}	2.98	2.20	42.12	3.64	5.07	56.55
K_{72}	2.98	3.80	44.07	4.26	5.75	63.57
K_{108}	3.09	4.12	62.40	3.73	3.79	68.25
Mean	2.97	3.44	47.19	4.05	4.74	59.57
$N_{216}P_{72}$ K_0	4.90	3.95	44.85	5.32	5.02	53.82
K_{36}	3.30	4.35	44.85	3.73	4.50	55.77
K_{72}	3.73	4.55	52.82	4.15	4.70	64.35
K_{108}	3.62	3.69	62.40	4.68	4.39	68.25
Mean	3.89	4.14	51.48	4.47	4.65	60.55
General mean	3.21	3.13	47.22	4.01	4.11	60.49

Effect of soil ploughing depth and NPK treatments on soil pH and EC:

Data presented in Table (3) show the mean values of soil pH and EC in the soil solution of surface layer (0-15 cm) after harvesting sugar beet crop. The results showed that soil pH and EC were decreased under deep ploughing (30 cm) compared to the shallow one (15 cm) without any addition of fertilizers, where soil pH was 8.87 and 8.70 while EC was 2.11 and 0.83 dS/m under shallow and deep ploughing, respectively. Decrease of soil pH under deep ploughing may be due to that the deep ploughing buried the organic matter deeper in the soil, where decomposition of organic matter in soil produced organic acids which led to decrease soil pH (Ali and Abo Habaga, 1995). On the other side, EC decreasing of soil solution may be due to increasing penetration of water under deep ploughing which led to leaching the salts through the soil profile.

Table (3): Mean values of soil pH and EC (dS/m) as affected by increment rates of NPK fertilizers after harvesting sugar beet crop.

NK treatments		Shallow ploughing (15 cm)				Deep ploughing (30 cm)			
N kg/ha	K kg K_2O/ha	P_1 (36 kg P_2O_5/ha)		P_2 (72 kg P_2O_5/ha)		P_1 (36 kg P_2O_5/ha)		P_2 (72 kg P_2O_5/ha)	
		pH	EC	pH	EC	pH	EC	pH	EC
72	0	8.80	0.77	8.57	1.21	8.55	0.58	8.51	0.81
72	36	8.66	1.03	8.96	0.93	8.52	0.67	8.56	0.55
72	72	8.68	1.18	8.40	1.45	8.60	0.80	8.26	0.64
72	108	8.66	0.89	8.62	0.91	8.53	0.68	8.59	0.86
Mean		8.70	0.97	8.64	1.13	8.55	0.68	8.48	0.72
144	0	8.71	1.21	8.60	0.73	8.41	0.68	8.58	0.63
144	36	8.77	0.85	8.83	0.98	8.66	0.53	8.50	0.85
144	72	8.78	0.62	8.80	0.99	8.25	0.55	8.44	0.62
144	108	8.79	1.33	8.63	1.14	8.44	0.88	8.58	0.80
Mean		8.76	1.00	8.72	0.96	8.44	0.66	8.53	0.73
216	0	8.61	0.96	8.60	1.18	8.57	0.56	8.58	1.03
216	36	8.53	0.84	8.70	0.76	8.50	0.68	8.59	0.58
216	72	8.86	0.63	8.80	0.68	8.57	0.60	8.57	0.67
216	108	8.82	0.75	8.60	0.86	8.66	0.62	8.55	0.67
Mean		8.71	0.80	8.68	0.87	8.58	0.62	8.60	0.74
General mean		8.72	0.92	8.68	0.99	8.52	0.65	8.53	0.73

Significance for	Parameters						
	D	P	T	D X P	T X D	T X P	T X D X P
Soil pH	*	*	ns	*	ns	**	ns
EC	*	**	**	**	ns	**	**

D = Ploughing depth T = NK treatments P = P-treatments
*, ** = significant and highly significant at 5% and 1%, respectively.

Application of NK fertilizers to the soil haven't significant decrease on soil pH but superphosphate fertilizer had a significant effect on decreasing soil pH in the surface soil layer (0-15 cm). This is because the acidity effect of superphosphate which dissolve to give a solution with pH value of about 1.48 (Lindsay, 1979). Statistical analysis showed that the interactions between P and NK fertilizers had highly significant effect on soil pH and also between ploughing operation and P only. The lowest value of soil pH was 8.25 under deep ploughing and 144 kg N/ha + 72 kg K_2O/ha + 36 kg P_2O_5/ha of added fertilizers. It can be concluded that, decreasing soil pH was considered an important goal for many agriculture practices in our soils which increases availability of most nutrients. Therefore, addition of acidic fertilizers such as superphosphate is an important goal not only to its acidulation effect but also to balanced fertilization with N and K fertilizers.

Statistical analysis in Table (3) showed that the relationships between NPK fertilizers and ploughing depths were highly significant in decreasing EC of soil solution.

The lowest value of soil EC (0.53 dS/m) was obtained at 144 kg N/ha + 36 kg P_2O_5/ha + 36 kg K_2O/ha treatment under deep ploughing at 30 cm. Heavy clay soil from Nile delta needs to deep ploughing to reduce the water table of ground water and hence decreasing the total soluble salts of soil solution. Decreasing the total soluble salts in the soil solution after harvesting the sugar beet crop, may be related to plant healthy growing and better uptake of nutrients.

Effect of soil ploughing depth and NPK treatments on soluble Ca^{++}, Mg^{++} and Na^{+}:

Data in Table (4) showed that the soil solution after harvesting of sugar beet plant contained higher amounts of soluble Ca^{++}, Mg^{++} and Na^{+} under shallow ploughing (15 cm) than its value under deep ploughing (30 cm) without any addition of fertilizers ($N_{.0}P_0K_0$ treatment). Soluble Ca^{++} was 4.60 and 4.2; soluble Mg^{++} was 6.10 and 3.80; soluble Na^{+} was 11.00 and 6.25 meq/L under shallow and deep ploughing, respectively. This decrease in soluble cations under deep ploughing may be attributed to improving soil permeability and hydraulic conductivity which increase the movement of soluble cations through the soil profile. These results were confirmed by those obtained by Agboola (1981) and Rezk *et al*. (1982).

Addition of different fertilizers at different rates led to decreasing soluble cations in the soil solution. That is clear from difference values between control treatment ($N_{.0}P_0K_0$) and general mean (Table 4). This may be attributed to good plant growth and hence more absorption of cations from soil solution and/or insoluble compounds precipitation such as Ca and Mg phosphates. Values of general means for soluble cations indicated that the order of decreasing was $Mg^{++} > Ca^{++} > Na^{+}$ (see Table 4).

The interaction between different fertilizer treatments and soil ploughing depths showed highly significant relationships in decreasing the amounts of soluble Ca^{++}, Mg^{++} and Na^{+} with one exception for Mg^{++} ion under ploughing depth and NK treatment.

Table (4): Effect of soil ploughing depth and different rates of NPK fertilizers on soluble Ca^{++}, Mg^{++} and Na^{+} (meq/L) in soil after harvesting sugar beet crop.

NK treatments		Shallow ploughing (15 cm)						Deep ploughing (30 cm)					
N kg/ha	K kg K_2O/ha	P_1 (36 kg P_2O_5/ha)			P_2 (72 kg P_2O_5/ha)			P_1 (36 kg P_2O_5/ha)			P_2 (72 kg P_2O_5/ha)		
		Ca^{++}	Mg^{++}	Na^{+}	Ca^{++}	Mg^{++}	Na^{+}	Ca^{++}	Mg^{++}	Na^{+}	Ca^{++}	Mg^{++}	Na^{+}
72	0	2.20	0.90	5.20	3.20	2.90	7.17	1.50	0.80	5.00	3.10	1.20	5.85
72	36	2.40	2.50	5.80	3.80	2.80	6.15	2.20	1.10	5.50	2.80	2.40	3.65
72	72	2.25	3.10	8.20	3.70	4.00	9.50	1.70	3.00	5.35	2.30	1.10	4.65
72	108	2.70	1.00	6.20	3.50	2.70	5.95	1.60	0.90	5.85	3.30	2.20	5.45
Mean		2.39	1.88	6.35	3.55	3.10	7.19	1.75	1.45	5.43	2.88	1.73	4.90
144	0	2.40	1.90	7.90	3.30	2.10	5.11	1.60	0.90	5.00	3.10	2.00	4.17
144	36	2.90	2.20	7.50	4.00	2.70	5.47	2.60	2.10	6.50	1.90	2.20	5.38
144	72	1.40	1.20	4.60	2.90	1.70	4.45	1.40	1.10	4.30	2.30	0.80	4.40
144	108	3.00	2.60	9.00	3.00	2.60	6.25	2.40	1.20	8.18	2.80	1.90	5.25
Mean		2.43	1.98	7.25	3.30	2.28	5.32	2.00	1.33	6.00	2.53	1.60	4.80
216	0	1.60	1.90	7.00	4.20	2.00	7.00	1.30	1.30	6.25	4.20	1.90	6.50
216	36	3.60	1.90	6.75	3.30	1.80	5.25	2.40	0.50	6.60	2.00	1.60	4.35
216	72	2.70	1.90	5.00	3.10	1.00	4.75	2.50	0.90	4.50	2.50	1.00	4.00
216	108	1.40	2.10	6.10	2.80	2.70	6.50	1.30	1.30	5.75	2.20	2.30	4.85
Mean		2.33	1.95	6.21	3.35	1.88	5.88	1.88	1.33	5.78	2.73	1.70	4.93
General mean		2.38	1.93	6.60	3.40	2.42	6.13	1.88	1.26	5.73	2.71	1.68	4.88

Significance for	Parameters						
	D	P	T	D X P	T X D	T X P	T X D X P
Ca^{++}	**	**	**	**	*	**	**
Mg^{++}	**	**	**	**	ns	**	**
Na^{+}	**	*	**	**	**	**	**

D = Ploughing depth T = NK treatments P = P-treatments

*, ** = significant and highly significant at 5% and 1%, respectively.

Calculated SAR and ESP after harvesting sugar beet crop:

The calculated values of SAR and hence ESP were decreased in the soil surface (0-15 cm) under deep ploughing at 30 cm compared to shallow ploughing at 15 cm (Table 5). This reflect the higher amounts of soluble Na^+ at shallow ploughing compared to deep ploughing (Table 4). The values of SAR were 4.76 and 3.14 without any addition of fertilizers ($N_0P_0K_0$) under shallow and deep ploughing, respectively. The corresponding values for ESP were 7.66 and 5.62%, respectively. That means, deep ploughing was succeeded in decreasing soil salinity and alkalinity compared to shallow one (Table 1).

Data showed that under the same treatments of P and soil ploughing depth, addition of NK fertilizers had higher significant effect on the calculated SAR and ESP. The lowest value of SAR (2.27) and ESP (4.44%) were obtained under deep ploughing and addition of 72 kg N/ha + 72 kg P_2O_5/ha + 36 kg K_2O/ha. On the other hand, P application had highly significant effect on SAR and ESP, where increasing P addition decreased calculated SAR and ESP (Table 5). Conformation of soluble phosphate compounds such as Na-Phosphates almost led to leaching more Na^+ ions and hence decreasing SAR and ESP. Statistical analysis showed that all interactions between NPK treatment and soil ploughing depth had highly significant effect on the calculated SAR and ESP.

Table (5): Calculated sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP%) as affected by soil ploughing depth and different rates of NPK fertilizers after harvesting sugar beet crop.

NK rates		Shallow ploughing (15 cm)				Deep ploughing (30 cm)			
N kg/ha	K kg K_2O/ha	P_1 (36 kg P_2O_5/ha)		P_2 (72 kg P_2O_5/ha)		P_1 (36 kg P_2O_5/ha)		P_2 (72 kg P_2O_5/ha)	
		SAR	ESP	SAR	ESP	SAR	ESP	SAR	ESP
72	0	4.23	6.97	4.09	6.80	4.70	7.62	4.01	6.71
72	36	3.71	6.36	3.40	5.92	4.30	7.06	2.27	4.44
72	72	5.02	8.00	4.86	7.79	3.52	6.10	3.58	6.14
72	108	4.58	7.67	3.38	5.88	5.27	8.30	3.31	5.79
Mean		3.46	7.25	3.93	6.60	4.45	7.27	3.29	5.77
144	0	5.43	8.46	3.12	6.87	4.54	7.39	2.60	4.89
144	36	5.69	7.58	2.99	5.39	4.25	7.02	3.82	6.49
144	72	4.12	6.83	2.93	5.30	3.84	6.49	3.59	6.18
144	108	5.38	8.43	3.73	6.37	5.87	9.01	3.62	6.23
Mean		4.91	7.83	3.19	5.98	4.63	7.48	3.41	5.95
216	0	5.30	8.38	3.99	6.67	5.47	6.83	3.73	6.37
216	36	4.08	6.81	3.29	5.79	5.49	8.55	3.25	5.71
216	72	3.30	5.79	3.31	5.84	3.48	6.01	3.10	5.52
216	108	4.63	4.49	3.93	6.63	5.04	8.05	3.23	5.70
Mean		4.33	7.12	3.63	6.23	4.87	7.36	3.33	5.83
General mean		4.54	7.40	3.59	6.27	4.65	7.37	3.34	5.85

Significance for	Parameters						
	D	P	T	D X P	T X D	T X P	T X D X P
SAR	**	**	**	**	**	**	**
ESP	**	**	**	**	*	**	**

D = Ploughing depth T = NK treatments P = P-treatments
*, ** = significant and highly significant at 5% and 1%, respectively.

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Depth and Quality of the Groundwater in North Delta Soils

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Abstract

Water table levels had been recorded daily on 227 locations in North Delta under different soil, land use and drainage conditions. The measurements were made in observation wells (perforated plastic tubes 38 mm diameter and 2 m deep). The measurements were started in November 1999 and will continue through the next two growing seasons. Ground water samples were collected (twice until now) from the observation wells. Salt content, concentration of the essential cations and anions, and the concentration of some heavy metals and microelements were determined.

The preliminary results for the first six months are presented here and the final results will be published after the end of the investigations. The obtained data revealed that the lands of the North Nile Delta region are characterized by a high water table. The mean water table level ranged between 33-150 cm with overall mean of 78 cm. Water table levels reach a maximum after irrigation and gradually decrease reaching a minimum before the next irrigation. Such trend was observed in all studied locations. The quality of ground water was influenced by the land use and drainage conditions, and also by the levels of the water table. Negative correlation was obtained between groundwater depth and quality of such water. The correlation coefficients between mean water table level and mean values of EC, Na, Ca+Mg, HCO_3, Mn, Fe, and Pb of the groundwater were 0.319, 0.296, 0.323, 0.359, 0.378, 0.244, and 0.069 respectively. The data of depth and quality of the ground water will be used to justify identifying the ground water as a resource to cover a part of the water requirements of the different field crops.

Introduction

In arid and semi-arid regions usually shallow water table is the decisive factor of salinization and alkalization. The limiting depth of groundwater table that might be considered of practical importance would vary with the nature of the soil and quality of groundwater, land use, irrigation and drainage conditions (Kovda, 1961 and Elgabaly, 1972). Most lands of North Delta region are clay textured soils, mainly under flood irrigation system and increased cropping intensity. Groundwater table level of 60–90 cm for sandy soils and of 100–150 cm for clay soils were considered suitable for most field crops (Benetin, 1983). The sub-irrigation from groundwater may greatly contribute in the water requirements of the plants. Ground water may be considered as a water supply source for crops and may reduce irrigation demand (Ragab and Amer, 1989; Ibrahim, 1999).

Specially in North Delta region, where water supplies become scarce, evaluation of the depth and quality of groundwater is necessary for effective water use and management. Therefore the objectives of this investigation are to: (1) evaluate the fluctuation of water table levels for 227 locations in North Delta, representing wide variations in land use, drainage conditions, and hence groundwater depth; (2) determine the quantitative relations between depth and quality of ground water.

Material and Methods

Water table levels had been recorded daily on 227 sites in Kafr El-Sheikh governorate, north Nile Delta, Egypt. The study sites were chosen to represent a wide variation in locations, land use, irrigation and drainage conditions. The measurements were made in observation wells (perforated plastic tubes 38 mm diameter and 2 m deep), which were installed at the half distance between two tiles (or open field drains). The measurements were started first November 1999 and will continue for at least one year. The data presented here cover the first six months. (November 1999 – April 2000). Ground water samples were collected from the observation wells at the beginning of December 1999 and at the end of April 2000. Salt content (EC value) and the concentrations of essential cations and anions were determined as the methods described by Richards (1954). Fe, Mn, Zn, Cu, Pb, Ni, Co, and Cd were determined by Atomic Absorption spectrophotometer. Statistical analyses were calculated for the relation between ground water depth and quality of such water. Correlation coefficients were calculated according to the method given by Snedecor and Cochran (1967).

Results and Discussion

Ground water depth varies from 5 cm to 191 cm according to the location, cultivated crop and drainage conditions. The average values of water table depths for the studied sites from beginning November 1999 until end April 2000 are presented in Fig. (1)[9]. These values ranged between 33 cm and 150 cm with overall mean value of 78 cm. The lands of studied locations were characterized by a high water table.

Table 1: Mean water table depth (M.W.T) and chemical analysis of such water in the main studied regions

Location	M.W.T (cm)	EC dS/m	Na^+ Meq/L	Ca^{++} + Mg^{++}	HCO_3 Meq/L	Mn (mg/L)	Fe (mg/L)	Pb (mg/L)
Dakalt	(89) 65-127	(2.6) 1.2-9.8	1.7-58	4.7-36	3.2-29	0.11-4.8	0.1-1.6	0.2-1.8
Kom Elwahal	(65) 33-83	(4.0) 1-8.8	6.9–57	2.5-27	2.6–30	0.1 – 4	0.17–2.5	0.1-2.2
El Ragama	(63) 42-123	(4.8) 1.6-13	10-72	5.1-47	7.5-30	0.1-2.9	0.26-1.3	0.1-2
Abo Moustafa	(67) 47-93	(7.0) 1.4-22	11-138	6.5-83	6-49	0.29-6.4	0.27-2	0.1-3.7
El Daba	(93) 44-144	(3.5) 1.3-8	8-48	5.9-31	4-28	0.1-3.9	0.1-1.3	0.1-3.1
GarbMansour	(96) 84-105	(6.7) 3-12	17-79	11.5-47	11-30	0.5-2.4	0.3-1.3	0.6-4.6
Aruamon	(79) 62-101	(2.6) 1-8.6	6.2-50	4.2-50	4.9-23	0.1-4.9	0.1-3.4	0.2-3.5
El Manifa	(82) 56-137	(1.7) 1.3-3.6	8-23	4.2-13	5.7-15	0.1-3.9	0.1-6.1	0.2-3.6
Ibto	(82) 40-150	(4.3) 1.3-16	8-93	5-38	5.6-30	0.21-3.5	0.25-2.2	0.1-2.7
El Taufa	(73) 45-144	(2.3) 1.3-3.7	7-22	4.8-13	5.3-13	0.1-2.8	0.13-2.9	0.2-3.4
Nosra	(86) 76-99	(1.9) 1.5-2.7	9-17	5.2-9	6.5-9	0.43-2.4	0.15-1.1	0.1-1.4
Sakha	(87) 80-96	(2.7) 1.9-4.2	11-24	6.8-14	6.7-16	0.5-0.9	0.2-1.1	3-3.8

[9] Figures 1-4 are only available in the print copy (Beihefte zu Der Tropenlandwirt Nr. 71)

The daily fluctuations of water table depth for some chosen sites are illustrated in figures (2) and (3). The depth of water table reached the deepest level of 90-150 cm before irrigation, it came close to soil surface upon irrigation and decreased gradually in between irrigations. Such trend was observed in all studied locations. The highest and lowest water table depth and drawdown rate of water table level varied according to cultivated crop, soil, irrigation and drainage conditions.
The 227 studied sites were regional divided into twelve main regions. Mean water table and chemical analysis of ground water in the main studied regions presented in Table (1) showed that water table depth and quality varied between these regions according to soil and drainage conditions as well as quality of irrigation water. High water levels of 63-67 cm with high salt content (mean EC value of 4-7 dS/m) were recorded in some regions such as Kom–Elwahal, El Ragama and Abo-Moustafa due to excessive use of bad irrigation water and not conserved drainage system. The studied locations in Garb-Mansour had newly reclaimed soil irrigated with mixed irrigation, but they had an adequate tile drainage system. The other studied regions had old alluvial soils irrigated with Nile water, and had mean water table level varied between 73-89cm with not bad quality (mean EC values of 1.7-4.3 dS/m). Groundwater analysis showed also that Na is the dominant cation. The Na exceeds the sum of Ca+Mg in all the studied locations. Groundwater is free of residual sodium carbonate (RSC) in some locations and contains different levels of RSC in other ones.

Negative significant relation between mean water table depth and EC values of such water was found (r = 0.320, and R-squared = 0.102) as illustrated in Fig. (4). Table (2) showed the data of regression analyses among mean water table level and chemical analysis of such water. The quality parameters of ground water were negatively correlated with the depth of such water. The correlation was found to be significant or high significant except for Pb. The correlation coefficients were 0.320, 0.296, 0.323, 0.359, 0.244, and 0.069 for EC, Na, Ca+Mg, HCO_3, Mn, Fe, and Pb respectively. The obtained low R-squared values mean that variations of groundwater quality can not be considered due to the depth of such water only. But it affected by many other factors such as soil, land use, irrigation and drainage conditions. In this concern, Oosterbaan (1988) concluded that if the water table becomes shallow the salt leaching can no longer occur and the salts accumulate in the soil and consequently in the ground water.

Table (2): Correlation of mean water table depth with quality parameters of such water.

Quality Parameter	Range	Average	Standard deviation	Correlation Coefficient	R-squared
EC	1.1-12.7	3.7	2.6	-0.320**	0.102
Na	6.7-77.8	23	15.6	-0.296**	0.088
Ca+Mg	3.9-47	13.2	9.2	-0.323**	0.104
HCO_3	3.2-33	12.2	6.7	-0.359**	0.129
Mn	0.01-4.7	1.3	0.96	-0.378**	0.143
Fe	0.01-2.5	0.79	0.46	-0.244*	0.059
Pb	0.01-4.6	1.07	0.89	-0.069 n.s.	0.005

** Significant at 1% level, * significant at 5%, n.s Non-significant.

Recent research has indicated that most crops have higher salt tolerance values than previously thought (Rhoades et al. 1989) which means that many drainage and ground waters are suitable for supplemental irrigation purposes. Water supply from groundwater can be evaluated as potential sources of irrigation water. Many researchers (Kruse et al. 1985; Ayars and Schoneman 1986; Ayars 1996) have shown that field crops will extract significant quantities of water from the shallow groundwater. Preliminary data of the present study revealed that groundwater quality in many of the studied regions is not bad. Results of this study strongly support the argument that groundwater may contribute on water requirements of field crops. This will be discussed in detail in a following study.

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