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Impact of Irrigation Water Quality, Nitrogen Fertilization Rates and Foliar Application of Ascorbic Acid on Wheat Yield and Some Soil Properties in the North Middle Nile Delta Region

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Lysimeter experiment was performed during winter season of 2015/2016 in Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate, to study the effect of irrigation water salinity, nitrogen fertilizer rates and foliar application of ascorbic acid on yield and its components of wheat crop and some soil properties. The experiments were designed as split-split plot with three replicates. The main plots were occupied by irrigation water salinity as: S1(0.56 dS m^{-1}), S2(2 dS m^{-1}), S3(4 dS m^{-1}), and S4(6 dS m^{-1}), sub plots were devoted to N-fertilization rates N1(75%N), N2(100%N), and 125%N recommended dose and sub-sub-plots ascorbic acid concentration A1(100 ppm) and A2(200 ppm).
The results can be summarized as follows

- Irrigation water salinity, N-fertilizer rates and foliar application of ascorbic acid have a high significant on grain and straw, biological yield and 1000-grain weight.

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- The highest value for grain and straw yield (2290.30 and 3190.22 kg fed^{-1}) was obtained with applying irrigation water (0.56 dS m^{-1}), as compared to irrigation water salinity levels (2, 4 and 6 dS m^{-1}), (2.4 Fed.= hectare).
- The highest value for grain and straw yield (29830.50 and 3172.20 kg fed^{-1}) were obtained by applying 125% N from recommended dose and (2785.38 and 2991.63 kg fed^{-1}) as foliar spraying of ascorbic acid (200 ppm).
- Grain yield was decreased by 4.04, 6.46 and 10.06%, under water salinity levels 2, 4 and 6 dS m^{-1}, respectively with irrigation water compared to fresh water (0.5 dS m^{-1}).
- The straw yield of wheat was reduced by 8.56, 10.95 and 19.86% under irrigation water salinity levels 2, 4 and 6 dS m^{-1} compared to fresh water (0.5 dS m^{-1}).
- The highest mean values for both water productivity (WP) and productivity of irrigation water (PIW) were recorded under irrigation water salinity S_1 and S_2 comparing with S_3 and S_4 treatments. Also both nitrogen rates and ascorbic acid as foliar application have had positive effect on both (WP) and (PIW) for grains and biological yield where the highest mean values were recorded with N_3 and A_2 treatments.
- The highest salt accumulation in soil profile under ECiw 2, 4 and 6 dS m^{-1}were increased by 14.23, 22.79 and 46.94%, respectively as compared to ECiw 0.56 dS m^{-1} while SAR values were increased by (6.97, 10.92 and 25.38%).
- The above mentioned results indicated that the applied leaching fraction 20 to 30% was not efficient to remove salts in the soil profile and further work needs to be done in order to maintain the acceptable salinity level in the root zone.
- The highest values of grain and straw, biological yield and weight of 1000-grain were achieved with ascorbic acid at 200 ppm as compared to 100 ppm.

Keywords: Wheat plants; irrigation water salinity; nitrogen rates; ascorbic acid.

1. INTRODUCTION

Salinity is considered a major factor in limiting plant growth and productivity, and salinization of irrigated and surrounding areas in the arid tropics and sub-tropics has not been diminished. On the contrary, it continues to increase in arid and semi-arid regions [1]. The increasing of irrigation salinity from 0.58 to 3.67 (dS m^{-1}) increased total soil salinity from 1.87 to 24.83 dS m^{-1}. Thus, the salts accumulation in soil was closely related to the salts concentration of irrigation water [2]. Salts in soil water reduce evapotranspiration by making the soil water less available for extraction by plant roots [3,4]. Salinity reduces plant growth by suppressing the rate of leaf elongation due to reduction of cell division and enlargement in leaves [3]. Many plants are able to building up higher internal solute contents, to partially compensate for low osmotic potential of soil water was found under salinity conditions [3]. The inherent ability of the crops to withstand the effects of elevated salt concentration within their root crop tolerance or resistance to salinity [5].

The effect of irrigation water quality on each soil salinity at each depth was determined. The results showed that all irrigated fields have differed in salt concentration as indicated by soil electrical conductivity (ECe) values of the saturated paste extracts. The soil salinity in some fields decreased and increased in other soils, and the distribution of salts through the soil profile in highly correlated with salinity of irrigation water and soil type [6]. Water stress has one of the greatest threats that emerged in many parts of the world especially in Egypt and it projected to double in future [7]. Impaired water supplies are growing obstacles to wheat production worldwide [8]. According to the saline irrigation water effect, data noticed that increasing water salinity rate associated with decreasing in wheat yield of both grain and straw by about 16.5 and 16.1% [9].

Bread wheat (*Triticum aestivum* L.) is the most widely grown and consumed as food crop and is the staple food 35% of the world population [10]. The national staple food for one-fifth of human population around the global [11]. The food and agriculture organization (FAO), during 2014/2015 growing season confirmed that 9.4 million tons of wheat was produced in 2015/2016 growing season in Egypt. Meanwhile, approximately 8.1 million ha of the Egyptian soil is cultivated with wheat [12]. It is noticeably that the Egyptian population increases, thus, the demand for wheat will be increased annually. Land has to expand the cultivated area with wheat, according to the Economic Affairs Sector, Ministry of Agriculture and Land Reclamation in Egypt [12]. The productivity could be increased through resistance to abiotic stresses [13].

Nitrogen (N) is one of the most yield-limiting nutrients for crop production in the world. It has been recognized as an essential nutrient for plant growth for more than a century. It is also the nutrient element applied in the largest quantity for most annual crops. Significant advances emerged in N fertilizer technology during the last half of the 20^{th} century. Furthermore, the essential role of N increasing crop production and its dynamic nature and property for N loss from the soil-plant system create a unique and challenging environment for its efficient management. In addition, efficient or optimal management of N in the agroecosystem is still a debatable issue [14]. Nitrogen use efficiency (NUE) may be affected by amount of applied N and water availability [15]. Likewise, many reports demonstrated a decline in NUE when N fertilizer rates are increased [16], since N becomes less limiting at high rates, [17] indicated that nitrogen efficiency indices positively affected by N fertilizer rate. Nitrogen efficiency indices decrease with increasing N level under water stress [18].

The application of high N levels may lead to less N uptake and low NuE due to high N losses [19,20]. [21] stated that the highest value of nitrogen agronomic efficiency (NAE) was obtained due to the irrigation after depletion 45% from available water +75% of N recommended dose.

Ascorbic acid as antioxidant plays a benefit impact on cell growth and division, differentiation and metabolism in plants [22]. [23] observed that foliar application of ascorbic acid ameliorates the adverse water stress due to stomata closure, nutrient uptake, total chlorophyll content, protein synthesis, transpiration, photosynthesis and plant growth. Ascorbic acid is regarded as one of the most effective growth regulators against abiotic stresses [24]. Ascorbic acid not only acts as an antioxidant but the cellular levels of ascorbic acid are correlated with the activation of complex biological defense mechanisms [25]. It has also been used to counteract the adverse effects of salt stress in many crop plants [26]. It has proposed functions in whole plant metabolism [27]. Furthermore, experimental studies on different plants have shown that exogenous application of ascorbic acid may reduce salt induced adverse effects and results in a significant increment of growth and yield [28].

2. MATERIALS AND METHODS

2.1 Experimental Site and Treatments

Lysimeter experiment was carried out during winter season of 2015/2016 in Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, which lies in 134 km north Cairo, Egypt. The site has an elevation of 6 meter above sea level with latitude of 31° 07` and longitude of 30° 57`. The study aimed to clarify the effect of different irrigation water salinity, nitrogen fertilization rates and foliar application of ascorbic acid on yield and yield components of wheat and salt accumulation and distribution with variable depth of soil. The experiment was conducted in split split plot design, with three replications. The main plots were assigned to irrigation water salinity S_1, S_2, S_3 and S_4ds/m, sub plots (N fertilizer levels): N_1, N_2 and N_3 and ascorbic acid concentration A_1 and A_2. Lysimeter was divided into 3 groups. The group includes 12 lysimeter to be studied. Lysimeter was a circular shape; the diameter of one meter and a height of 60 cm with filter (sand and gravel) of 10 cm, each lysimeter was filled by 458.25 kg of the clay soil. The area of lysimeter was determined using the formula: Area = $\Pi \times r^2$. Nitrogen recommendation for wheat 90 kg N fed^{-1}, (1 ha = 2.4 fed.). Urea fertilizer was used as a source of nitrogen. Table 1 shows the experiment design.

Foliar application of ascorbic acid was sprayed three times using hand atomizer, wetting agent and booting stages after 30, 45 and 60 days from sowing under S_1, S_2, S_3 and S_4 treatments.

Wheat (*Triticum aestivum* L.) variety Sids 12 was sown on 15^{th} November at 2015 and harvested on 20^{th} April, 2016 The other required cultural practices for growing wheat were followed properly as recommended for the region. The following data were recorded: grain yield, straw yield, biological yield kg fed^{-1} and 1000-grains weight (g). The meteorological data from Sakha station during the growing season are presented in Table 2.

Table 1. The experimental design

Irrigation water salinity	
S_1	0.56 dS m^{-1}
S_2	2.0 dS m^{-1}
S_3	4.0 dS m^{-1}
S_4	6.0 dS m^{-1}
N fertilizer levels	
N_1	75% nitrogen recommended dose (67.5 kg N fed^{-1}.)
N_2	100% nitrogen recommended dose (90 kg N fed^{-1}.)
N_3	125% nitrogen recommended dose (112.5 kg N fed^{-1}.)
Ascorbic acid	
A_1	100 ppm
A_2	200 ppm

Table 2. Climatological data for the growing season in 2015/2016

Date	Air temp. °C		Mean	RH %	Wind velocity (km/day) at 2 m height	Pan evapo. mm/day	Rain mm
	Max.	Min.					
Nov. 2015	24.4	14.42	19.41	75.60	70.30	0.319	52.4
Dec. 2015	19.7	8.36	14.03	77.90	57.90	0.250	25.0
Jan. 2016	18.4	6.35	12.38	74.05	69.20	0.252	46.0
Feb. 2016	22.58	9.35	15.97	69.05	58.80	0.252	0.00
Mar. 2016	24.50	11.60	18.05	69.90	63.20	0.359	13.8
Apr. 2016	30.03	18.62	24.33	61.70	87.10	0.594	0.00

2.2 Soil Sampling and Analysis

Before the treatment random soil samples (0-20, 20-40 and 40-60 cm depth) were collected, dried, sieved through 2 mm mesh and were analyzed for texture, pH, EC [29]. The bulk density was measured using core-ring method and one core per status of each plot was collected and the samples were oven dried for 48 h at 105°C, weighed and bulk density calculated according to reference [30], particle size distribution was determined according to [31], and presented in Tables 3 and 4.

Sea water was diluted to ECiw = 2, 4 and 6 dS m^{-1} and fresh water as a control was used for irrigation are shown in Table 5.

Table 3. Some chemical, physical and soil moisture characteristics of soil before planting (2015/2016)

Soil depth (cm)	pH 1:2.5	EC dS m^{-1}	SAR	Particle size distribution (%)			Texture grade	Soil moisture characteristics			Bulk density g/cm^3
				Sand	Silt	Clay		Field capacity (%)	Wilting point (%)	Available water (%)	
0-20	8.05	3.56	9.99	18.87	31.51	49.62	Clay	42.86	20.35	22.51	1.15
20-40	8.11	3.79	10.31	17.52	30.21	52.27	Clay	38.95	21.76	17.19	1.25
40-60	8.20	4.15	10.78	14.32	28.76	56.92	Clay	37.89	23.15	14.74	1.36
Mean	8.12	3.83	10.36	16.90	30.16	52.94	Clay	39.90	21.75	18.15	1.26

Table 4. Chemical analysis of different irrigation water salinity

Treat	pH	EC dS m^{-1}	SAR	Cations (meq/L)				Anions (meq/L)			
				Na^+	K^+	Ca^{++}	Mg^{++}	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
S_1	7.45	0.56	3.96	3.8	0.4	1.2	0.7	-	1.5	2.7	1.9
S_2	7.75	2.00	7.49	13.6	0.6	4.2	2.4	-	2.5	9.5	8.8
S_3	7.86	4.00	10.59	27.2	0.8	8.4	4.8	-	3.5	19.0	18.7
S_4	8.05	6.00	12.97	40.8	1.2	12.6	7.2	-	5.0	30.1	26.10

Table 5. The volume of sea water for specific irrigation volume and ECiw according to its salt content in growing season 2015/2016

EC sea dS m^{-1}	Cosea.* g/L	ECiw dS m^{-1}	Required EC irrigation	Required vol/L	Vol of sea water L/required volume in L**
0.0	0.0	0.56	0.56	20	-
55.8	35.712	0.56	2.00	20	0.521
55.8	35.712	0.56	4.00	20	1.245
55.8	35.712	0.56	6.00	20	1.970

**Concentration of sea water **: The different required volume (L) mixed with 20L fresh water to obtain the required Ec for irrigation*

Table 6. Potential evapotranspiration (ETo) and maximum evapotranspiration (ETm) for wheat crop during growing season (2015/2016)

Month	Period	Pan evap		Pan coefficient (K pan)	Potential evap. (ETo)	Crop coefficient Kc	Maximum evapotrans (ETm)	
		cm/day	cm/ period				cm	m^3
Nov.	15-30/11	0.319	4.785	0.75	3.589	0.4	1.436	60.31
Dec.	1-31-12	0.250	7.750	0.75	5.813	0.8	4.65	195.32
Jan.	1-31/1	0.252	7.812	0.75	5.859	1.2	7.03	295.26
Feb.	1-29/2	0.252	7.308	0.75	5.481	1.2	6.58	276.36
Mar.	1-31/3	0.359	11.129	0.75	8.347	0.75	6.26	262.92
April.	1-20/4	0.594	11.880	0.75	8.910	0.25	2.23	93.66
Total season							28.186	1183.812

Wheat was planted and received 8 irrigations were applied during the growing season. The total applied water (field water applied and amount of precipitation/season) were (1938.60 and 403.37 m^3/season) 2342.1 m^3/fed and potential evapotranspiration (ETo) and maximum evapotranspiration (ETm) for wheat are shown in Table 6.

Water productivity (WP) and productivity of irrigation water (PIW). It was calculated according to [32].

$$WP = Gy/ET$$

Where:

WP = Water productivity (kg grain/m^3 WCU)
GY = Grain yield (kg fed.$^{-1}$)
ET = Total water consumption of the growing season (m^3 fed^{-1})
PIW = Gy/I
PIW = Productivity of irrigation water (kg grains)/m^3 water applied
Gy = Grain yield (kg fed^{-1})
I = Irrigation water applied (m^3 fed^{-1})

2.3 Salt Movement

Salt movement was calculated as the differences between the mean values of EC (dS m^{-1}) for soil layers (0-20, 20-40, and 40-60 cm) before planting and after harvesting to study the soil quality under irrigation water salinity levels [33].

2.4 Statistical Analysis

The results were analyzed statistically by a general linear model procedure and 2-way analysis of variance (ANOVA) using Cohort Computer Program according to the method of [34]. Mean separation procedures were performed using LSD's test at 0.05 and 0.01 level of significance.

3. RESULTS AND DISCUSSION

3.1 Yield and Yield Components

Irrigation by fresh water (I_1) helped producing, grain, straw, biological yields and 1000-grain yield and that by saline water (6 dS m^{-1}, I_4) suppressed them to the lowest values followed by I_3 (Tables 7 and 8).

Under I_2 and I_3, and I_4, the grain yield decreased by 4.04, 6.46 and 10.06%, respectively compared to I_1.

The straw yield of wheat reduced by 8.56, 10.85 and 14.86% under I_2, I_3 and I_4, respectively compared to I_1. I_1 and I_2 produced invariant straw yields, while I_3 and I_4 produced similar but highly significantly lower straw yield than I_1. There were highly significantly differences in grain and straw yields under irrigation water salinity levels of 2, 4 and 6 dS m^{-1}, respectively in this study. The biological yield was decreased by 6.41, 8.76 and 12.85% under I_2, I_3 and I_4, respectively compared to I_1. The 1000-grain weight decreased by 1.13, 2.57 and 5.29% under I_2, I_3 and I_4, respectively compared to I_1. It is noted that although irrigation water of 4 dS m^{-1} augmented most of the growth and yield attributes of wheat tillering and hence spike density, which, consequently, reduced the grain, straw and biological yields of the crop. This function depicted that as salinity level of irrigation water increased, the yield level of wheat was decreased.

These results are in agreement with findings of [35,36] who obtained 32 and 63% reduction in grain yield of wheat under 8 and 12 dS m^{-1} salinity, respectively compared to the non-saline treatment. [37] found that the significant damages of wheat only with irrigation water salinity of 12 dS m^{-1} or more, salinity level $\leq$7 dS m^{-1} exerted insignificant impact on the grain yield of wheat. [38] obtained significant differences in grain and straw yields under irrigation water salinity of 3, 8 and 12 dS m^{-1}.

Application of nitrogen highly significantly increased grain and straw yields of wheat. Maximum grain and straw yields (2983.49 and 3172.50 kg fed^{-1}, respectively, biological yield (6155.90 kg fed^{-1}), and 1000 grain weight (64.89 g) were found with the application of N_3 (112.5 kg N fed^{-1}). All previous parameters significantly increased with increasing of N fertilizer level from 67.5 kg N to 112.5 kg N fed^{-1} (Table 7).

Table 7. Yield and their components of wheat as affected by different treatments

Treatments	Grain yield (kg fed^{-1})	Straw yield (kg fed^{-1})	Biological yield (kg fed^{-1})*	1000-grain weight (g)
Salinity of irrigation water				
S_1	2900.3 a	3190.22 a	6090.52 a	64.95 a
S_2	2778.16 b	2916.29 b	5695.10 ab	64.26 a
S_3	2708.11 c	2843.50 c	5551.61 bc	63.32 a
S_4	2586.66 d	2716.60 d	5303.26 c	58.21 b
F-test	**	**	**	**
L.S.D. 0.05	6.62	6.94	283.10	2.95
L.S.D. 0.01	10.03	10.51	428.90	4.47
Nitrogen fertilization levels				
N_1	2542.16 c	2702.29 c	5244.50 c	59.22 b
N_2	2704.30 b	2875.33 b	5579.63 b	63.84 a
N_3	2983.49 a	3172.50 a	6155.90 a	64.79 a
F-test	**	**	**	**
L.S.D. 0.05	10.20	10.89	221.30	2.15
L.S.D. 0.01	14.05	15.01	304.80	2.96
Ascorbic acid concentration				
A_1	2701.20 b	2871.77 b	5573.00 a	61.26
A_2	2785.38 a	2961.63 a	5747.01 a	64.10 a
F-test	**	**	**	**
L.S.D. 0.05	6.82	7.14	175.30	1.72
L.S.D. 0.01	9.25	9.68	2.32	2.34
Interaction				
S x N	**	**	NS	NS
S x A	**	**	NS	NS
N x A	NS	NS	NS	NS
S x N x A	**	**	NS	NS

**: biological yield as the sum of grain and straw yield*

Results presented in Table 6 show the grain yield of wheat increased by 6.03 and 10.13% under N_2 and N_3, respectively compared to N_1. The straw yield increased by 6.05 and 10.33% under N_2 and N_3 that compared to N_1. The biological yield and 1000-grain weight increased by 6.04, 10.23, 5.29 and 1.82% under N_2 and N3, respectively compared to N_1.

The results show that opportunity exists for managing N fertilizer inputs more efficiently with wheat production. Wheat grain yield to be the result of number of effective tillers, number of grains per spike and grain weight [39]. As shown in Tables 7 and 8 significantly higher yield of wheat was recorded with the highest N levels (112.5 kg fed^{-1}).

External supply of ascorbic acid to wheat plants appreciably enhanced grain and straw yield (Tables 7 and 8). The application of ascorbic acid at 200 ppm increased grain and straw yields by 4.07 and 3.10% when compared to 100 ppm, respectively. The positive effect of ascorbic acid on grain and straw yields may be attributed to its role in translocation of metabolites from leaves into reproductive organs. Moreover, synthesis of protein which improve grain and straw yields. These results agreed with the findings of [40,23]. Ascorbic acid showed a positive effect on accumulated soluble proteins which play a vital role in osmotic adjustment and may be associated with absorption of nutrients [41,42].

Concerning the interaction effects between irrigation water salinity and nitrogen fertilizer on grain and straw yields of wheat data show that the grain and straw yields were highly significantly increased under S_1 and N_3 treatments. There was high significant effect between irrigation water salinity and foliar ascorbic acid on the grain and straw yields of wheat and interaction effect between irrigation water salinity, nitrogen fertilizer and ascorbic acid on the grain and straw yields since it were highly significant increased the biological yield and 1000-grain weight (Table 7).

3.2 Regression Correlation between Relative Wheat Yield and Salinity Levels of Irrigation Water

Data of relative decrement of yield versus water salinity levels were evaluated throughout linear equation for wheat as shown in Fig. 1.

The relative yield decrement % represent the dependent variable while the salinity expressed in dS m^{-1} represent the independent variable and the equation takes the following formula.

$$Y = a x + b$$

Where:

Y = Relative yield decrement %
x = Salinity of irrigation water
a = Slope (yield reduction % with increasing ECw one unit)
b = The intercept

The regression equation that fit the interaction is

$$Y = 100.32 - 1.7472 x$$

Where:

Y = predicted seasonal yield (kg)
x = water salinity (dS m^{-1})

It is clear that highly significant correlation was seen between relative yield decrement and water salinity levels (R^2 = 0.9797).

Table 8. Effect of irrigation water salinity, nitrogen fertilization and ascorbic acid concentration on relative yield and its components of wheat crop

Treatments	Grain	Straw	Biological	1000-grain weight (g)
S_1	100.00	100.00	100.00	100.00
S_2	95.96	91.44	93.59	98.87
S_3	93.54	89.15	91.24	97.43
S_4	89.94	85.14	87.15	92.12
N_1	93.97	93.95	93.96	94.71
N_2	100.00	100.00	100.00	100.00
N_3	110.13	110.33	110.23	101.82
A_1	100.00	100.00	100.00	100.00
A_2	104.07	103.10	103.57	103.19

S_1 = 0.56 dS m^{-1}, S_2 = 2 dS m^{-1}, S_3 = 4 dS m^{-1}, S_4 = 6 dS m^{-1}
N_1 = 75% recommended dose, N_2 = 100% N, N_3 = 125% N
A_1 = 100 ppm ascorbic acid, A_2 = 200 ppm ascorbic acid

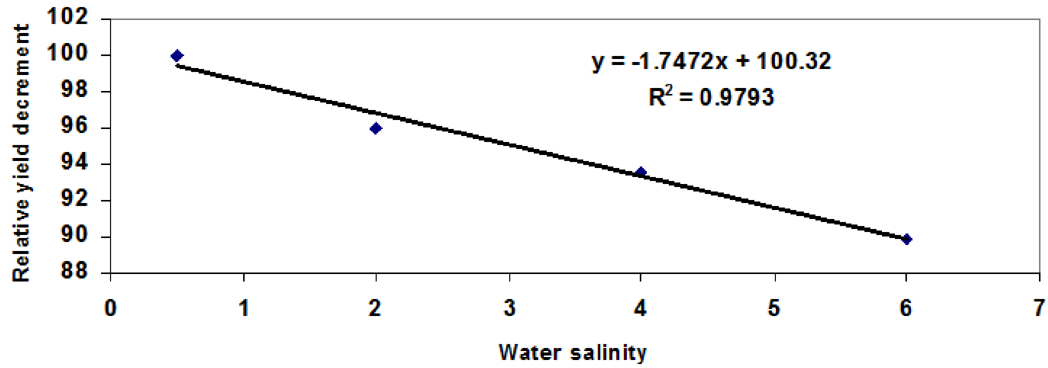

Fig. 1. Relative yield decrement % as affected by irrigation water salinity

3.3 Water Productivity (WP) and Productivity of Irrigation Water (PIW)

Data in Table 9 show that irrigation water salinity, nitrogen fertilization and ascorbic acid concentration had effect on water productivity and productivity of irrigation water whereas the mean values of WP and PIW were increased under irrigation water salinity S_1 and S_2 compared with S_3 and S_4 treatments, N_3 and N_2 compared with N_1 and A_2 compared with A_1 treatments.

These increases in WP and PIW might be due to the decrease in the amount of water consumptive use and water applied for wheat crop. This result is in full agreement with that of [35].

3.4 Salt Accumulation and Distribution in Soil Profile

3.4.1 Soil salinity and sodicity

Data presented in Table 10 and Fig. 2 illustrated the irrigation water salinity of 6 dS m^{-1} has caused greatest soil salinity at the end of season and irrigation water salinity levels 2, 4 and 6 dS m^{-1} increased soil salinity by 14.23, 22.79 and 46.94%, respectively as compared with ECiw 0.56 dS m^{-1}. The salinity of top layer (0-20 cm) with all treatments was lower than salinity of subsoil layer (20-40, and deepest layer (40-60 cm) (Fig. 2). The highest differences between salinity of top soil layer and deeper soil layer occurred at irrigation water salinity of 6 dS m^{-1}, respectively.

Table 9. Water productivity (WP), productivity of irrigation of water (PIW) of wheat under different treatments

Treatments	Water productivity (WP) (kg/m^3)		Productivity of irrigation water (PIW) (kg/m^3)	
	Grains	Biological	Grains	Biological
	Irrigation water salinity			
S_1	2.450	5.145	1.228	2.600
S_2	2.357	4.811	1.186	2.432
S_3	2.288	4.689	1.156	2.370
S_4	2.188	4.479	1.104	2.264
	Nitrogen fertilization levels			
N_1	2.147	4.430	1.085	2.239
N_2	2.284	4.713	1.155	2.382
N_3	2.520	5.200	1.274	2.628
	Ascorbic acid concentration			
A_1	2.282	4.708	1.153	2.379
A_2	2.353	4.855	1.189	2.454

Table 10. Effect of irrigation water salinity on soil salinity and the rate of change (%) under wheat with the different soil depths

Treatment	Soil depth (cm)	Soil salinity dS m^{-1}		
		Before exp.	After harvest	Rate of change %
ECw 0.56 dS m^{-1}	0-20	3.52	3.70	5.11
	20-40	3.94	4.25	7.87
	40-60	4.41	4.78	8.39
Mean		3.96	4.24	7.12
ECw 2 dS m^{-1}	0-20	3.56	3.91	9.83
	20-40	4.32	4.97	15.05
	40-60	4.55	5.36	17.80
Mean		4.14	4.75	14.23
ECw 4 dS m^{-1}	0-20	3.34	3.71	11.08
	20-40	3.84	4.76	23.96
	40-60	4.11	5.48	33.33
Mean		3.76	4.65	22.79
ECw 6 dS m^{-1}	0-20	2.94	3.55	20.75
	20-40	3.49	5.46	56.45
	40-60	3.93	6.43	63.61
Mean		3.45	5.15	46.94

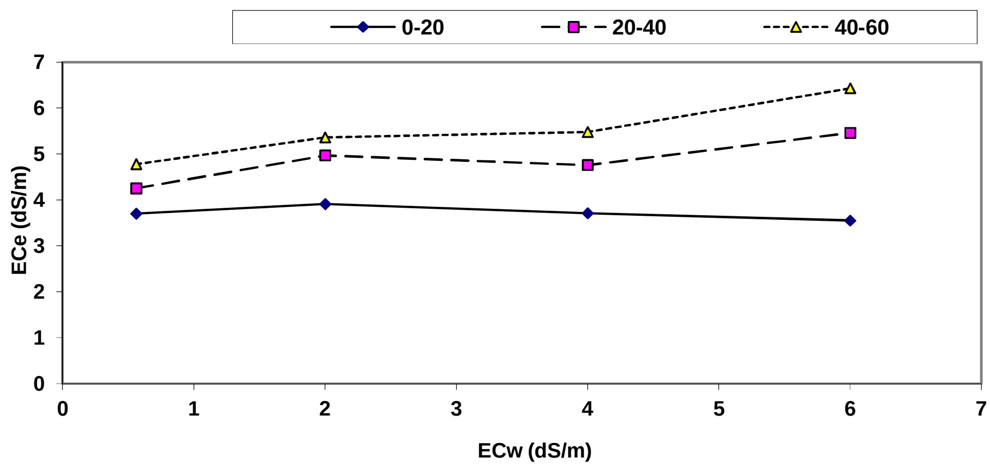

Fig. 2. Effect of water salinity on soil salinity

Data in Table 11 and Fig. 3 indicate that the use of irrigation water salinities of 2, 4 and 6 dS m^{-1} increased the SAR to 6.97, 10.92 and 25.38%), respectively as compared with ECiw 0.56 dS m^{-1}. The SAR values in top soil layer were lower than the deepest layer soil (Fig. 3). These results are in agreement with those obtained by [43,8].

3.5 Effect of Irrigation Water Salinity on Soil Quality

Mean comparison tests between irrigation treatments indicate that irrigation water salinity to 2, 4 and 6 dS m^{-1} increased soil salinity compared to the control irrigation water (0.56 dS m^{-1}).

There were increase in of soluble sodium, calcium, and magnesium due to the addition of sea water in the irrigation. This indicated that the applied leaching fraction (20 to 30%) was not efficient at removing salts in the soil profile and extersive study needs to be conducted in order to assess the acceptable leaching regime.

Leaching can decrease soil salinity effectively by improving the quality of irrigation water. Increased leaching levels can be useful to certain limits. Leaching efficiency higher was reduced by increasing irrigation water salinity in these soils without accumulation of salt in soil profile. Appropriate leaching fraction in connection with suitable irrigation water salinity can be used as an effective tool to manage soils of arid regions.

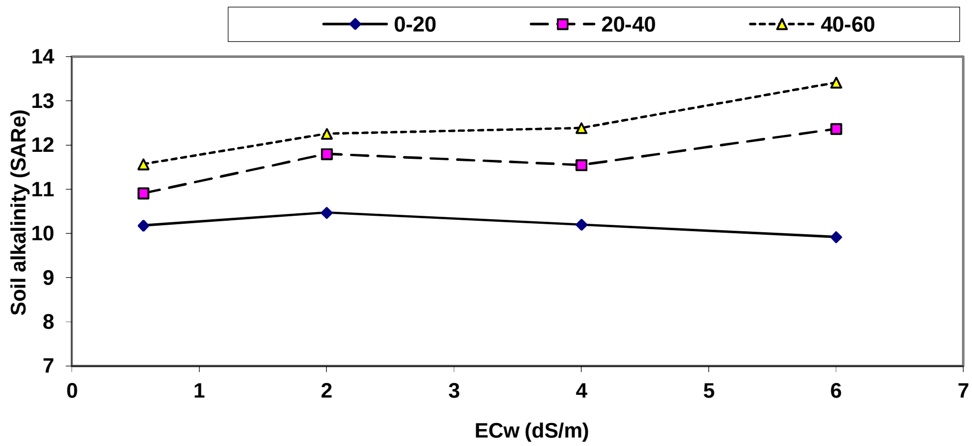

Fig. 3. Effect of water salinity on soil sodicity

Table 11. Effect of irrigation water salinity on soil sodicity and the rate of change (%) under wheat crop with the different soil depths

Treatments	Soil depth (cm)	Soil alkalinity dS m^{-1}		
		Before exp.	After harvest	Rate of change %
ECw 0.56 dS m^{-1}	0-20	9.93	10.18	2.52
	20-40	10.51	10.91	3.81
	40-60	11.12	11.57	4.05
Mean		10.52	10.89	3.52
ECw 2 dS m^{-1}	0-20	9.99	10.47	4.80
	20-40	11.00	11.80	7.27
	40-60	11.29	12.26	8.59
Mean		10.76	11.51	6.97
ECw 4 dS m^{-1}	0-20	9.67	10.20	5.48
	20-40	10.37	11.55	11.38
	40-60	10.73	12.39	15.47
Mean		10.26	11.38	10.92
ECw 6 dS m^{-1}	0-20	8.06	9.92	23.08
	20-40	9.89	12.37	25.07
	40-60	10.49	13.42	27.93
Mean		9.46	11.92	25.39

4. CONCLUSION

It could be concluded that the application of 112.5 kg N fed^{-1}+ foliar application of ascorbic acid (200 ppm) achieved production of wheat without adverse effect under irrigation water salinity at North Delta, Egypt.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rus AM, Rios S, Olmos E, Santa-Cruz A, Bolarin MC. Long term culture modifies the salt responses of callus lines of salt tolerant and salt sensitive tomato species. J. Plant Physiol. 2000;157:413-420. Available:http://dx.doi.org/10.1016/S0176-1617(00)80026-7
2. Ragab AAM. Physical properties of some Egyptian soils. Ph.D. Thesis, Fac. Agric., Cairo Univ., Egypt; 2000.
3. Allen RG, Pereira LS, Raes D, Smith M. Crop evapotranspiration: Guideline for computing crop water requirements. Irrigation and drainage paper no. 56, FAO, Rome, Italy; 1998.
4. Heidarpour M, Mostafazadeh-Fard B, Arzani A, Aghakhani A, Feizi M. Effects of irrigation water salinity and leaching

fraction on yield and evapotranspiration in spring wheat. J. Communic. Soil. Sci. Plant Anal. 2009;40:2521-2535.

5. Steppuhn H, van Genuchten MT, Grieve CM. Root-zone salinity: Selecting a product-yield index and response function for crop tolerance. J. Crop Sci. 2005;456: 209-220.
6. Al-Ghobari HM. The effect of irrigation water quality on soil properties under center pivot irrigation systems in central Saudi Arabia. Water Resources Management V1 507-516. WTT Transactions on Ecology and the Environment. 2011;145. WTT Press www.witpress.com, ISSN 1743-3541 (on line)
DOI: 10.2495/wrm.11441
7. Varga BP, Vida G, Varga E, Beneze S, Veisz G. Effect of simulating drought in various phenophases on the water use efficiency of winter wheat. J. Agroc. Crop Sci. 2015;201:1-9.
8. Gian X, Song KL, Wang TC, Turner NE, Li FM. Effect of drought on the gas exchange, chlorophyll fluorescence and yield of six different Era spring wheat cultivars. J. Agro. Crop Sci. 2015;201:253-266.
9. Mansour HA, Abd El-Hady M. Performance of irrigation systems under water salinity in wheat production. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) e-ISSN: 2319-2380, p. ISSN: 2319-2372. 2014;7(7):19-24.
10. Rajarm S, Sayre KD, Die Kmann J, Gupta R, Erskine W. Susceptibility considerations in wheat improvement and production. In: M.S. Kang, Ed., Agricultural and Environmental Sustainability-Considerations for Future, Haworth Food and Agricultural Products Press, New York. 2007;105-124.
11. FAO. Food and agriculture organization statistics; 2014.
Available:faostat3.taq.org.download/q/qe/e
12. FAO. Food and agriculture organization statistics. Faostat; 2015.
Available:www.fao.org/faostat
13. Siahpoosh MR, Dehghanianb E. Water use efficiency, transpiration efficiency and uptake efficiency of wheat during drought. Agron. J. 2011;104:1238-1243.
14. Fageria NK. The use of nutrients in crop plant. CRC Press, Taylor and Francis Group, LLC, 6000 Broken Sound Parkway, NW; 2009.
15. Kibe AM, Singh S, Kalra N. Water-nitrogen relationships for wheat growth and productivity in late sown conditions. Agr. Water Manag. 2006;84:221-228.
16. Waraich EA, Ahmad R, Ahmad SA. Water stress and nitrogen management effects on gas exchange, water relations and water use efficiency in wheat. J. Plant Nutr. 2011;34(12):1867-1882.
17. Hafez E, Kobata T. The effect of different nitrogen sources from urea and ammonium sulfate on the spikelet number in Egyptian spring wheat cultivars on well watered pot soils. Plant Prod. Sci. 2012;15(4):332-338.
18. Zhang J, Sha Z, Zhang Y, Bei Z, Cao L. The effects of different water and nitrogen levels on yield water and nitrogen utilization efficiencies of spinach (*Spinacia oleracea* L.). Can. J. Plant Sci. 2015;95: 671-679.
19. Giulinani MM, Giuzio L, Decaro A, Flagella Z. Relationships between nitrogen utilization and grain technological quality in durum wheat. Nitrogen translocation and nitrogen use efficiency for protein. Agron. J. 2011;103(5):1487-1494.
20. Abou El-Hassan WH, Hafez EM, Gharieb AAA, Freeg MR, Seleiman MF. Impact of nitrogen fertilization and irrigation on water utilization efficiency, N accumulation, growth and yields of *(Zea mays,* L.). J. Food Agric. Environ. 2014;12(3,4):212-222.
21. El-Agrodi MWM, Saied MM, Ahmed GL, Khalifa TSH. Effect of soil moisture depletion and nitrogen levels on wheat (*Triticum aestivum*, L.). J. Soil Sci. and Agric. Eng., Mansoura Univ. 2016;7(2): 169-178.
22. Athar HR, Khan A, Ashraf M. Inducing salt tolerance in wheat by exogenously applied ascorbic acid through different modes. J. Plant Nutr. 2009;32:1799-1817.
23. Xu Y, Xu G, Huag B. Ascorbic acid mitigation of wheat stress-inhibition of root growth in association with oxidative defense in tall fescue (*Festula arundinacea* Schreb.). Frontiers in Plant Science. 2015;6(807):1-14.
24. Conklin PL. Recent advances in the role and biosynthesis of ascorbic acid in plants. Plant Cell Environ. 2001;24:383-394.
Available:http://dx.doi.org/10.1046/j.1365-3040-2001.00686.x
25. Conklin PL, Borth C. Ascorbic acid, a familiar small molecule intertwined in the

response of plants to ozone, pathogens and the onset of senescence. Plant Cell Environ. 2004;27:959-970. Available:http://dx.doi.org/10.1111/j.1365-3040.2004.01203.x

26. Beltagi MS. Exogenous ascorbic acid (vitamin C) induced anabolic changes for salt tolerance in chick pea (*Cicer arietinum*, L.) plants. Afr. J. Plant Sci. 2008;2:118-123.
27. Debolt S, Melino V, Ford CM. Ascorbate as a biosynthetic precursor in plants. Ann. Bot. 2007;99:3-8. Available:http://dx.doi.org/10.1093/aob/mc1236
28. Salama KHA. Amelioration of NaCl-induced alterations on the plasma membrane of *Allium cepa* L. by ascorbic acid. Aut. J. Basic. Appl. Sci. 2009;3:990-994.
29. Page ALR, Miller H, Keeney DR. Methods of soil analysis. Part 2: Chemical and Microbiological Properties. 2nd Edition. Agronomy Monograph, No. 9, ASA, CSSA, CSSA and SSSA, Madison; 1982.
30. Blake GR, Hartge KH. Bulk density, In: A. Klute, et al. Eds. Methods of Soil Analysis. Part I, ASA and SSSA, Madison. 1986; 363-375.
31. Piper CS. Soil and plant analysis. Inter Science Publication, New York: Reddy, B.V.S.; Reddy, P.S. Bidinger, F; 1950.
32. Ali MH, Hoque MR, Hassan AA, Khair A. Effects of deficit irrigation on yield, water productivity and economic returns of wheat. Agricultural Water Management. 2007; 92(3):151-161.
33. Black LJ. Methods of soil analysis. Amer. Soc. Agron. Inc. Madison, Wisconsin, U.S.A; 1965.
34. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd Edition. John Wiley and Sons, New York. 1984;680.
35. Mojid MA, Murad KFI, Tabriz SS, Wyseure GCL. An advantageous level of irrigation water salinity of wheat cultivation. J. Bangladesh Agric. Univ. 2013;11(1):141-146.
36. Phogat V, Satyawan S, Kumar S, Sharma SK, Kapoor AK, Kuhal MS. Performance of upland cotton and wheat genotypes under different salinity conditions. Indian J. Agric. Sci. 2001;71:303-305.
37. Flagella Z, Vittozzi LC, Platini C, Fonzo ND. Effect of salt stress on photosynthesis electron transport and grain yield in durum wheat (*Triticum durum).* Proceeding of the Conference on Irrigation Research: Pocess in the Use of Water Resources, Bari, Italy. 2000;47:31-36.
38. Behrouz M, Hamed M, Mousavi SF, Feizi M. Effects of different levels of irrigation water salinity and leaching on yield and yield components of wheat in an arid region. J. Irrig. Drain. Eng. 2009;135:1-32.
39. Ahmad N, Basra SMA, Qureshi RH, Ahmad S. Grain development in wheat as affected by different nitrogen levels under warm dry conditions. Pak. J. Agric. Sci. 1988;25:225-231.
40. Dolatabadion A, Jouneghani RS. Impact of exogenous ascorbic acid on antioxidant activity and some physiological traits of common bean subjected to salinity stress. Not. Bot. Hori. Agrobo. 2009;37:165-172.
41. Batool EJ, Ahmad Z, Faheem AFT. Effect of exogenous application of ascorbic acid on antioxidant enzyme activities, proline contents and growth parameters of Saccharum spp. hybrid cv. HSF-240 under salt stress. Turk. J. Biol. 2012;36:630-640.
42. Malik S, Ashraf M. Exogenous application of ascorbic acid stimulates growth and photosynthesis of wheat (*Triticum aestivum* L.) under drought. Soil Environ. 2012;31(1):72-77.
43. Dordipour H, Ghadiri M, Bybordi H, Siadat M, Malakouti J, Hussin J. The use of saline water from the Caspian sea for irrigation and barley production in northern Iran.13th International Soil Conservation Organization Conference-Brisbane. 2004; 986:1-4.

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