QUANTITATIVE RELATIONS OF ADDED N FERTILIZER AND SOIL–N FOR WHEAT PLANTS IRRIGATED WITH DIFFERENT SALINE WATER IN EGYPT

***Mashali S.; A.Balba; E.Elwakil; R.Atia and A. Abou Elkhir**

ABSTRACT

A factorial greenhouse pot experiment was carried out at Fac. Agric. Kaferelsheikh, Egypt in winter season to investigate the efficiencies and quantitative relations of the added N fertilizer (0, 30, 60 and 90 kg N/acre) and soil – N on wheat yield wheat crop was irrigated with tap water (W_o) and three artificial saline water(W_1,W_2 and W_3) with three levels of salinity(C_1,C_2 and C3) for every one. All treatments were replicated three times. The results can be summarized as following:

- The calculated grain yield when no fertilizer added, was decreased when salinity levels and sodicity of irrigation water increased .
- The maximum yield was decreased when salinity level of irrigation water increased.
- The maximum addition of N fertilizer decreased due to increasing salinity and sodicity of irrigation water.
- The useful of soil – N was decreased when salinity level of irrigation water increased and also with the type of irrigation water according to the following order: $W_0 > W_1 > W_2 > W_3$.
- The efficiency of added – N fertilizer decreased when added N levels increased while this efficiency increased as salinity levels of irrigation water increased.
- The contribution of N – fertilizer in yield production was increased when salinity levels of irrigation water increased. On the other hand, the contribution of soil - N was decreased when salinity and added N increased. As the fraction of added N-fertilizer increased the fraction of soil - N decreased with the same ratio.

***Mashali,S**.; A.Balba; E.Elwakil; R.Atia and A. Abou Elkhir
Soil Science Dept., Faculty of Agriculture, Kaferelsheikh Univ., 33516-Kaferelsheikh, Egypt
E-mail: smashali@yahoo.com

Key word: Quantitative relations, Wheat crop, Added – N , Soil – N, Saline water, Egypt.

I. INTRODUCTION

Wheat crop is the most important cereal crop in Egypt and increasing wheat production is an essential national target to fill the gap between production and consumption (Abou–Khadrah et al., 1999). Under the conditions of arid and semi-arid regions, as in Egypt, irrigation water is a limiting factor for agriculture expansion. . The use of low water quality such as drainage water might be requested. About 7.7 billion m^3 of drainage water are expected to be used for irrigation in Nile Delta of Egypt (Abu Zeid, 1988). Crop yield might be doubled when satisfactory amounts of fertilizer-N are applied and are greatly decreased without N fertilization (Balba, 1981) especially when saline water used for irrigation.

Therefore, the objectives of the present study were to investigate the efficiencies and quantitative relations of the added-N fertilizer and soil–N on the yield of wheat crop irrigated with different saline water.

II. MATERALS AND METHODS

Surface sample from non saline silty clay soil (11.0, 47.0 and 42.0% sand, silt and clay, respectively) at Kafrelsheikh, Egypt was collected. Soil sample was air dried, sieved through a 2 mm screen for analysis and pot experiment. Soil characteristics and irrigation water used are given in Table 1.

Table (1): Characteristics of Soil and irrigation water used in the experiment

Soil characteristics		Water characteristics					
		WQ*	SL**	Added cations, meq/L			SAR
				Ca++	Mg++	Na+	
pH (1:2.5 soil suspension)	8.17	W_0	C_0	1.65	1.00	1.62	1.41
EC (soil paste) dS/m	2.93	W_1	C_1	9.98	9.33	9.96	3.20
Total carbonate %	2.40		C_2	18.31	17.67	18.29	4.31
O.M %	2.11		C_3	26.65	26.00	26.62	5.19
CEC c mole/kg	49.60	W_2	C_1	6.65	6.00	16.62	6.61
Saturation capacity %	70		C_2	11.65	11.0	31.62	9.40
$NaHCO_3$-extracted soil P mg/kg	21.0		C_3	16.65	16.0	46.62	11.54
Total N mg/kg	924.40	W_3	C_1	4.43	6.56	18.29	7.86
K_2SO_4extracted Soil N mg/kg	99.0		C_2	7.21	12.11	34.95	11.24
			C_3	9.98	17.67	51.62	13.88

W_0 = Tap water , W_1 = 1:1:1; W_2= 1:1:3; W_3= 1:2:6 of $CaCl_2$:$MgCl_2$:NaCl, respectively.
C_o, C_1, C_2 and C_3=4.27,29.27,54.27 and 79.27 meq/L, respectively.
* =Water quality, **= Salinity level

Plastic pots were filled with 4 kg of air dried soil sample. Wheat grains (Var. Sakha 8) were planted. Pots were irrigated with corresponding saline water treatments at saturation capacity until 15 days before harvesting. Four levels of nitrogen (N_1= 0, N_2 = 30,N_3 = 60 and N_4 = 90 kg N/ac..) as urea fertilizer in 2 equal doses were added. Each pot was fertilized with the recommended doses of P and K. The plants were harvested after maturity and the grain yield was weighted.

The main physical and chemical characteristics were determined according to Page et al. (1984). All the obtained data were statistically analyzed as completely randomized design according to Snedecor and Cochran (1971).The quadratic polynomial equation has been frequently used for describing the yield response of wheat to application of different nitrogen rates. Its general form is given by:

$$Y_i=B_o + B_1 X_i+B_2 X_i$$

Where Y_i is the yield corresponding to nutrient rate, X_i is the rate of nutrient X, B_o is the intercept coefficient, B_1 is the linear coefficient and B_2 is the quadratic coefficient (Thabet and Balba,1994).

The maximum addition of fertilizer (X_m), the maximum yield (Y_m), the optimum addition of fertilized (X_0), the optimum yield (Y_0) the average efficiency (Ex), the soil nutrient content (Xs) and the contribution of soil N and fertilizer can be calculated from the following equations respectively:

$$X_m = -\frac{B_1}{2B_2},\ Y_m = B_0 - \frac{B_1^2}{4B_2},$$

$$X_o = \frac{P_r - B_1}{2B_2},\ Y_o = B_o + \frac{P_r^2 - B_1^2}{4B_2}$$

where P_r is the price ratio which calculated from the following equation:

$$\text{The price ratio (Pr)} = \frac{\text{Price of fertilizer unit}}{\text{Price of one ton of crop}}$$

$$e\overline{x} = B_1 - B_2X,\ ex = B_1 - 2B_2X$$

$$Ex = \frac{1}{10}\sqrt{B_1^2 - 4B_0B_2},$$

$$Xs = \frac{-B1 \pm \sqrt{B_1^2 - 4B_oB_2}}{2B_2}$$

The mathematical derivatives mentioned above were applied on grain yield to calculate some important derivatives according to Balba and Thabet (1995),Capurro and Voss(1981) and Thabet and Balba(1994).

III. RESULTS AND DISCUSSION

III.1. The polynomial equation and their derivatives:

Table 2 shows the experimental and calculated wheat yield values obtained from the polynomial quadratic equation.The standard error (SE) of the estimated values and Chi-square test showed that, the calculated yield values from each polynomial equations do not significantly differ from those experimental values.

On the other side, Table 3 shows the polynomial quadratic equations that were established to express wheat response to nitrogen level under the different water qualities with their salinity levels.

Generally, Tables 3 shows that the B_0 values (intercept) or the amount of the yield when the fertilizer–N units equal zero decreased with the salinity levels increased. These values depended on soil–N only which decreased with increasing salinity levels at different water qualities applied.

Also, data in Table 3 indicated that the maximum yields (Y_m) obtained by addition of maximum- N rates (X_m) was decreased with increasing salinity and sodicity of irrigation water (Table 1).

The wheat requirement from N-fertilizer was decreased due to raising salinity and sodicity of irrigation water and its efficiency (ex) increased (Table 4). Similar results were obtained by Abou-Khadrah *et al*. (1999)and Elsikhry (1999).

The calculated soil–N (X_s) from polynomial quadratic equations was decreased with increasing salinity levels as different water qualities used.(Table 3). The B_0 and X_s decreased due to the salt composition according to the following order: W_0 > W_1> W_2 >W_3. These values are related to the SAR (Table 1).

The efficiency of N–fertilizer (ex) is defined as the average change in yield obtained per unit change of the applied nutrient (Thabet and Balba,1994),the value of ($e\overline{x}$)

which found in Table 4 are the average efficiency of the fertilizer application rate(X) and Ex which indicate the relative efficiency are shown in Table (4). Data in Table 4 showed that the ex value almost increased when salinity levels increased. Also, the values of $e\bar{x}$ increased when salinity levels increased.

Table (2): Experimental and calculated grain yield as affected by, water quality, water salinity levels and levels of added-N

Treatments		Experimental grain yield g/pot				Calculated grain yield g/pot			
WQ*	SL**	N0	N1	N2	N3	N0	N1	N2	N3
W0	C0	5.7	9.3	13.8	16.2	5.6	9.8	13.4	16.4
W1	C1	5.2	8.9	13.4	16.2	5.1	9.3	13.0	16.0
	C2	4.6	8.4	12.9	15.8	4.5	8.8	12.5	15.4
	C3	3.9	8.0	12.4	15.3	3.8	8.3	12.1	15.1
Mean		4.57	8.4	12.9	15.4	4.4	8.8	12.5	15.5
W2	C1	5.1	8.8	13.5	15.7	4.9	9.3	12.98	15.9
	C2	4.5	8.4	12.9	15.3	4.4	8.8	12.50	15.4
	C3	3.9	8.0	12.6	15.0	3.8	8.4	12.20	15.1
Mean		4.5	8.40	13.00	15.33	4.4	8.9	12. 6	15.5
W3	C1	4.8	8.9	12.9	15.5	4.7	9.1	12.7	15.6
	C2	4.2	8.7	12.6	15.3	4.2	8.8	12.5	15.3
	C3	3.8	8.1	12.3	14.8	3.7	8.3	12.1	14.9
Mean		4.27	8.57	12.6	15.2	4.2	8.7	12.4	15.3

* =Water quality, **= Salinity level of water

Table (3): The polynomial equations corresponding to water quality ,salinity levels, and nitrogen levels and some derivatives for grain yield.

WQ*	SL**	Polynomial equations	X_m Unit N/pot	Y_m gm/pot	X_s unit N/pot
W_0	C_0	$Y= 5.550 + 4.500 X - 0.300 X^2$	7.500	22.425	1.145
W_1	C_1	$Y= 5.055 + 4.605 X - 0.325X^2$	7.085	21.367	1.023
	C_2	$Y= 4.460 + 4.710 X - 0.350X^2$	6.657	20.306	0.889
	C_3	$Y= 3.795 + 4.895 X - 0.375X^2$	6.527	19.769	0.735
Mean			6.756	20.481	0.882
W_2	C_1	$Y= 4.925 + 4.775 X - 0.375X^2$	6.367	20.125	0.959
	C_2	$Y= 4.365 + 4.815X - 0.375X^2$	6.420	19.821	0.847
	C_3	$Y= 3.765 + 5.065 X - 0.425X^2$	5.959	18.856	0.702
Mean			6.249	19.601	0.836
W_3	C_1	$Y= 4.735 + 4.735 X - 0.375X^2$	6.313	19.682	0.931
	C_2	$Y= 4.170 + 5.070 X - 0.450X^2$	5.633	18.451	0.770
	C_3	$Y= 3.720 + 5.070 X - 0.450X^2$	5.633	18.000	0.691
Mean			5.860	18.711	0.797

*** =Water quality, **= Salinity level**

Xm=the maximum addition of fertilizer, Ym=the maximum yield, Xs=the soil nitrogen content.

The value of $e\bar{x}$, ex and Ex presented in Table 4 indicated that the wheat grains utilization from N – fertilizer application enhanced when salinity levels of irrigation water increased .We can say that the addition of N – fertilizer to wheat plant raised its tolerance to salinity and sodicty effects.

Table (4): The values of calculated efficiencies (ex,$e\bar{x}$ and Ex) of added N-fertilizer as affected by different treatments.

WQ*	SL**	ex (g/N unit/pot)				$e\bar{x}$	Ex
		N_0	N_1	N_2	N_3	g/N unit/pot	
W_0	C0	4.50	3.90	3.30	2.70	3.60	0.519
W_1	C1	4.61	3.96	3.31	2.66	3.63	0.527
	C2	4.71	4.01	3.31	2.61	3.66	0.533
	C3	4.90	4.13	3.40	2.65	3.77	0.545
	Mean	4.74	4.04	3.34	2.64	3.69	0.535
W_2	C1	4.78	4.03	3.28	2.53	3.65	0.549
	C2	4.82	4.07	3.32	2.57	3.69	0.545
	C3	5.07	4.21	3.36	2.52	3.79	0.566
	Mean	4.89	4.10	3.32	2.54	3.71	0.553
W_3	C1	4.74	3.99	3.24	2.49	3.61	0.543
	C2	5.07	4.17	3.27	2.37	3.72	0.576
	C3	5.07	4.17	3.27	2.37	3.72	0.569
	Mean	4.96	4.11	3.26	2.41	3.68	0.563

* =Water quality, **= Salinity level,ex=the average change of yield, $e\bar{x}$ =the average efficiency of fertilizer and Ex=the relative efficiency of fertilizer

Contribution Of soil – N and fertilizer –N added in grain yield:

The contribution of the original soil N and applied N – fertilizer to the wheat grain yield at each rate of N application (Table 5) were calculated using Xs values (Table 3) and calculated yield (Table 2) according of Thabet and Balba (1994).Results showed that the contribution of N – fertilizer increased when salinity level increased with different water qualities. On the other hand, the water qualities arranged in the following order $W_0 < W_1 < W_2 < W_3$. Also, the contribution of N – fertilizer increased with increasing nitrogen levels. Data indicated that the contribution of soil - N decreased with salinity levels increased. The utilization of soil – N decreased when added nitrogen level increased (Table 5).

The data in table (5) calculated as a functions and presented in Table (6) according to the following equations:

The contribution of soil N = $\frac{X_s}{X_f + X_s}$ x the calculated yield.

The contribution of fertilizer = $\frac{X_f}{X_f + X_s}$ x the calculated yield.

These fractions illustrated the aforementioned results in Table 5.Generally ,as the fraction of fertilizer increased the fraction of soil N decreased with the same ratio. Finally, it could be mentioned that the quantitative approach frequently utilization to know the economic optimum yield and the efficiency of fertilizer under the irrigation of drainage water.

Table (5): Contribution of soil-N and fertilizer–N to the grain yield at different treatments (gm/pot).

Treatments		Contribution of fertilizer (g/pot)				
WQ*	SL**	N0	N1	N2	N3	Mean
W0	C0	0.0	4.54	8.49	11.84	6.22
W1	C1	0.0	4.61	8.59	11.90	6.28
	C2	0.0	4.67	8.64	11.90	6.30
	C3	0.0	4.79	8.84	12.13	6.44
Mean		0.0	4.69	8.69	11.98	6.34
W2	C1	0.0	4.76	8.77	12.04	6.39
	C2	0.0	4.77	8.78	12.04	6.40
	C3	0.0	4.94	9.03	12.27	6.56
Mean		0.0	4.82	8.86	12.12	6.45
W3	C1	0.0	4.71	8.69	11.88	6.32
	C2	0.0	4.97	9.03	12.20	6.55
	C3	0.0	4.93	8.96	12.10	6.50
Mean		0.0	4.87	8.89	12.06	6.45
		Contribution of soil N (g/pot)				
W0	C0	5.55	5.21	4.86	4.51	5.03
W1	C1	5.06	4.73	4.38	4.05	4.56
	C2	4.46	4.15	3.84	3.54	4.00
	C3	3.80	3.53	3.25	2.98	3.39
Mean		4.44	4.14	3.83	3.52	3.98
W2	C1	4.93	4.57	4.21	3.84	4.39
	C2	4.37	4.04	3.73	3.40	3.88
	C3	3.77	3.47	3.17	2.87	3.32
Mean		4.36	4.03	3.70	3.37	3.86
W3	C1	4.74	4.39	4.04	3.69	4.22
	C2	4.17	3.82	3.48	3.13	3.65
	C3	3.72	3.41	3.10	3.78	3.25
Mean		4.21	3.87	3.54	3.20	3.71

* =Water quality, **= Salinity level of water

Table (6): Contribution fraction of soil N and fertilizer to the grain yield at different treatment

Treatments		Contribution fraction of fertilizer				
Water quality	Salinity level	N_0	N_1	N_2	N_3	Mean
W_0	C_0	0.00	0.466	0.636	0.724	0.457
W_1	C_1	0.00	0.494	0.662	0.746	0.476
	C_2	0.00	0.529	0.692	0.771	0.998
	C_3	0.00	0.576	0.731	0.803	0.528
Mean		0.00	0.533	0.695	0.773	0.501
W_2	C_1	0.00	0.510	0.676	0.758	0.486
	C_2	0.00	0.541	0.702	0.780	0.506
	C_3	0.00	0.587	0.740	0.810	0.534
Mean		0.00	0.546	0.706	0.783	0.509
W_3	C_1	0.00	0.518	0.682	0.763	0.491
	C_2	0.00	0.565	0.722	0.796	0.521
	C_3	0.00	0.591	0.743	0.813	0.537
Mean		0.00	0.558	0.716	0.791	0.516
		Contribution fraction of soil N				
W_0	C_0	1.000	0.534	3.640	0.276	0.543
W_1	C_1	1.000	0.506	0.338	0.254	0.524
	C_2	1.000	0.471	0.308	0.229	0.502
	C_3	1.000	0.424	0.269	0.197	0.472
Mean		1.000	0.467	0.305	0.227	0.499
W_2	C_1	1.000	0.490	0.324	0.242	0.514
	C_2	1.000	0.459	0.298	0.220	0.494
	C_3	1.000	0.413	0.260	0.190	0.466
Mean		1.000	0.454	0.294	0.217	0.491
W_3	C_1	1.000	0.492	0.318	0.237	0.509
	C_2	1.000	0.435	0.278	0.204	0.479
	C_3	1.000	0.409	0.257	0.187	0.463
Mean		1.000	0.442	0.284	0.209	0.484

REFERENCES

*Abou-Khadrah,S.H.;S.A.Abd El-Hafez; F. A. Sorour and A.Z.Bably(1999). Influence of irrigation with saline water on wheat yield, its components and nutrient uptake. International Symposium On nutrient Management under salinity and water stress. Techion-Israel Institute of Technology. Hefa 1-4 March : pp 299-310 .

*Abu-Zeid, M. (1988). Egypt's policies to use low quality water for irrigation. Proc. Symp. Re-use of low quality water for irrigation. Water Res. Center ,Cairo, Egypt.

*Balba, A. M. (1981). Nitrogen relations with soil and plant. Alex. Sci. Exch. 2(1):1-23.

*Capurro, E. and R. Voss (1981). An index of nutrient efficiency and its application to corn yield response to fertilizer N.1:Derivation,estimation and application,Agronomy J.73:128-135.

*Elsikary, E. M. (1999). wheat yield and its chemical composition as affected by irrigation water – salinity and P foliar application in a calcareous soil. J. Agric. Sec. Mansoura univ., 24(7):3737-3746.

*Page, A.L.; R.H Miller; D.R. Keeney (1984). Methods of Soil Analysis. Madison, WI, USA .

*Snedecor, G.W. and W.G Cochran (1971). Statistical Methods 6th Ed.Ioea State Univ. press; Ames, Iowa, USA.

*Thabet, AG. And A.M. Balba (1994).Soil and fertilizer – N efficiencies using wheat grain response equations to N and tillage .Arid Soil Research and Rehabilitation 8:115-124.