Sustainability of Soil Fertility after 3- Years Crop Rotation at El- Serw Research Station East North Delta of Egypt

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ABSTRACT

Long-term field trials were carried out at East North Delta of Egypt (El Serw Research station) throughout six years, to study the soil fertility under different resource managements, i.e. 4 levels of N and P fertilization (0, low, medium and high), water quality (fresh and drainage) and 3 crop rotations Rot.1 (wet), Rot.2 (wet wet) and Rot.3 (dry). The available N and residual P were significantly increased with increasing N and P fertilizers levels after the first cycle, while that of K was not affected. However, after the second cycle, N residuals and OM content were significantly increased with increasing fertilizer rates, while, P and K were not affected. Drainage water application caused a significant increase in the residual N by 31% and 11%, while Fe- content was decreased by 50% and 49% respectively compared to fresh water application after the first and second cycle of 3-years crop rotation. Fresh water application increased the residuals of O.M, P and K after the two cycles of the 3- years crop rotation compared to drainage water application. Crop Rotation 2 (wet wet) recorded a significant increase in OM and N in soil compared to Rot. 1 (wet) and Rot. 3 (dry), while Rot. 3 (dry) recorded significant increase in residuals P and K compared to Rot.1 and Rot. 2. Crop rotation 2 (wet wet) significantly increased residual Zn compared to Rot.1 and Rot.3, while residuals of Mn and Fe were not affected after the two cycles of 3- years crop rotation. The added N recorded remarkable RC% for residual N, (47%) followed by Zn (10.38%) and the RC% of the added P was (69%) for residual P and (22.99%) for residual Zn.

Key words: N and P fertilizers, soil fertility, water quality and crop rotation.

INTRODUCTION

In North Delta of Egypt, relatively saline water is commonly used for the agricultural irrigation due to the limited fresh Nile water supply. However, the uses of saline water reflected in increasing soil salinity which may result in deteriorating the soil from the long continued use of such water in irrigation (20). With increasing salt concentration, the uptake of Na and Cl ions increased sharply (12). This luxury consumption of ions is essential for the plants to compensate for the increased out-side osmotic pressure but is responsible for growth retardation. Excessive uptake of certain ions in turn, often results in reduced uptake of some essential plant nutrients, censing nutrient imbalances and deficiencies.

Management of salt affected soils requires a combination of agronomic practices, depending on a careful definition of the requirements based on a detailed, comprehensive prior investigation of soil characteristics, water quality and local conditions including climate, crops and human aspects. There is usually no single way to control salinity, particularly in irrigated agriculture. However, several practices can be combined into an integrated system functions satisfactorily (15). Crop rotations have positive effect on yield, even when soil fertility is at a measured optimum, and when pests and diseases are controlled. Agriculture production system in Egypt is very intensive, due to the favorable conditions that allow cropping during the whole year. The rotation effect alleviates the yield depression associated with continuous cultivation (4 and 18). After six crop cycles of maize- wheat rotation supplied with different NPK levels were studied by (10), they found that the available Zn and Mn content of the plough layer decreased considerably from its initial level. The greatest available Mn content depletion was at the highest N application rate. Zn and Mn- content also decreased with increased P rates. The introduction of modern high yielding varieties affects the nutrient balance by removing more nutrients with higher biomass (11). The main objective of the present work is to promote sustainability of soil fertility of salt affected soils under balanced NP fertilizers, water quality, and intensive cropping systems in North Delta (El Serw Research station).

MATERIALS AND METHODS

A long- term trial was conducted for two cycles of 3 years crop rotation, at East North Delta of Egypt at El Serw Research Station under tile drainage system, to study the sustainability of soil fertility status under the following resource managements:

1- Irrigation water quality: (a) Fresh water (FW) from irrigation canal and (b) Drainage water (DW) from the main El Serw drainage.

2- Crop rotation: Three types of crop rotation were applied as follows:

year	Prevailing (wet) Rot.1	Wet wet Rot.2	Dry Rot.3
1st	Egyptian clover followed by Rice	Egyptian clover followed by Rice	Faba bean followed by Rice
2nd	Wheat followed by sunflower	Egyptian clover followed by Rice	Sugar beet followed by sunflower
3rd	Egyptian clover followed by Rice	Egyptian clover followed by Rice	Egyptian clover followed by cotton

3- Chemical fertilizers

Balanced rates of N and P fertilizers according to crop requirements (Table 1) were added at 4 levels: zero (0), Low (L), Medium (M) and high (H). Phosphorus was added pre – planting to all crops, while nitrogen fertilizer was applied at the proper time to all crops. The experimental layout was split- split plot design in 4 replicates. The main plot area of 350m^2 were arranged for irrigation water quality. The subplots were devoted to the crop rotation, while the sub-sub plots were assigned to N and P fertilizer levels.

Soil analysis: Soil surface samples (0- 30cm) were collected from each plot before planting (0- time), after the first and the second cycles then subjected to chemical analysis such as OM% and available macronutrients (N, P and K) according to were determined according to Jackson, (1973) and DTPA –extractable micronutrients (Fe, Zn and Mn) according to Lindsay and Norvell, (1978).

Water analysis: Water samples also were collected monthly from the middle of the stream of the Main El Serw drain. These samples were analyzed to study their suitability for irrigation according to U.S. Salinity lab. (1954).

Monitoring soil fertility: Soil fertility status was examined after two cycles of 3- years crop rotation und some resources managements i.e. water quality (fresh and drainage), crop rotations {prevailing (wet) Rot. 1, (wet wet) Rot.2 and (dry) Rot.3} and balanced N and P fertilizer levels (0, low, medium and high). After 2 cycles of 3- years' crop rotation (3- and 6 years) soil surface samples (30 cm) were taken from each plot and subjected to chemical analyses individually. The available soil macronutrients (N, P and K) and DTPA-extractable micronutrients (Fe, Zn and Mn) as well as soil organic matter content (OM%) were analyzed using the conventional methods as indicator for the soil fertility build up.

Statistical Analysis: Average values of the four replicated of each treatment were interpreted using the analysis of variance (ANOVA) with separation of means accomplished by using LSD at 5% according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

As shown in Table (2), it can be concluded that water of El Serw drain can be used in soil with high permeability and adequate drainage. Special management for salinity control may be needed and moderate amount of water leaching must be occurred.

(1) Effect of crop rotation on soil fertility build up:

Application of the crop rotation Rot.2 (wet wet) showed slight superiority over the other two crop rotations on the available N content as a result of Egyptian clover occurrence (legume crop) in this rotation and showed also significant increase on the OM% after the first cycle of the 3- year crop rotation (Table 3).

Table 1: Fertilizer rates for all crops in the crop rotations.

Crops	Low level kg/ha		Medium level kg/ha		High level kg/ha	
	N	P_2O_5	N	P_2O_5	N	P_2O_5
			Winter crops			
Wheat	72	24	144	48	216	72
Clover	24	24	48	48	72	72
Faba bean	24	36	72	72	108	108
Sugar beet	72	24	144	48	216	72
			Summer crops			
Sunflower	36	24	72	48	108	72
Rice	60	24	120	48	180	72
Cotton	72	24	144	48	216	72
Rot. 1	276	144	552	288	828	432
Rot.2	252	144	504	288	756	432
Rot.3	288	156	576	316	864	468

Table 2: Irrigation water characteristics during winter and summer seasons of El- Serw experimental Farm.

Irrigation Source	EC ds/m	T.S.S ppm	SAR	Soluble cations percentage			
				SCaP	SMgP	SNaP	SKP
Winter season							
Canal water	0,64	410	3,00	30,76	15,44	50,93	2,86
Drainage water							
November	2,36	1510	10,19	8,08	19,25	71,01	1,67
December	2,25	1408	10,42	8,28	17,93	72,68	1,11
January	2,48	1587	9,67	12,78	19,64	66,11	1,47
February	2,64	1690	10,00	12,92	19,46	66,39	1,23
March	2,07	1325	9,78	10,55	18,46	69,52	1,46
April	2,41	1542	9,84	12,42	18,85	67,32	1,41
Summer season							
Canal water	0,65	416	3,58	24,16	18,31	55,28	2,25
Drainage water							
May	2,62	1677	11,74	5,94	18,67	74,03	1,36
June	3,22	2061	11,96	6,64	20,69	71,62	1,05
July	3,30	2112	12,21	6,49	20,51	71,85	1,15
August	2,42	1549	11,07	4,31	21,04	73,53	1,11
September	2,02	1293	9,84	12,36	14,68	71,74	1,22
October	2,28	1459	10,59	8,86	17,18	72,69	1,27

Table 3: Effect of different crop rotations on soil fertility build up after 2- cycles of 3- year crop rotation at El Serw research station experimental farm.

Crop rotation	O.M, %	Available nutrients					
		Macronutrients, $\mu g g^{-1}$			DTPA-extractable, $\mu g g^{-1}$		
		N	P	K	Zn	Fe	Mn
First cycle							
Zero- time	1,72	39,8	18,8	629	0,80	15,8	6,27
Wet	1,99a	35,4	17,5a	668ab	0,98a	10,5	14,1
Wet wet	2,15b	39,4	14,1a	632a	1,39b	10,3	13,5
Dry	1,94a	34,8	21.7b	690b	1,28b	10,8	15,0
Second cycle							
Wet	1,74	32,3	10,7	583,2	0,97a	10,5	14,1
Wet wet	1,76	33,4	11,3	580,1	1,38c	10,0	13,2
Dry	1,76	33,0	11,8	589,7	1,28b	10,7	14,8

Similar results were obtained by Carpenter, *et al.* (2000), Quintern, *et al.* (2006), and Boawn and Brown (1969) who pointed out the biggest organic matter content was registered in the crop rotation containing alfalfa, while the application of the dry rotation (Rot.3) gave the higher significant p content (21,7 ppm) and also higher significant K content (690 ppm) than the two rotation (Rot 1 and Rot.2). Similar results were obtained by Ebelhar (1997), Aynehband and Rashed (2003), Reddy and Surekha, (2000) and El Kholy, (1997).

Concerning the micronutrients content, the obtained data in Table (3) showed that DTPA-Fe content was not affected by crop rotation. However, Fe- content decreased comparing with the zero- time samples especially under drainage water used for irrigation. The crop rotations showed no significant effect on DTPA-Mn- content, but Mn content recorded higher values than that of zero–time samples after the first cycle. On the other hand, crop rotations showed significant effect on Zn-soil content since Rot.2 (wet wet) and Rot.3 (dry) increased DTPA-Zn- content by about 42% and 31% respectively comparing to Rot.1. Data in Table (6) indicated that crop rotation gave the highest RC% for organic matter (24.76%) followed by P (21, 24%) and N (7.43%), while it was the least in Mn (5.38%).

After the second cycle of the 3- crop rotation, the application of the crop rotation showed no significant effect on the available residuals of (N, P and K) and organic matter content. However, the amount of available (N, P and K) and organic matter showed lower values compared with the values after the first cycle, this may be due to the higher removed amounts of these nutrients during the 6 years cultivation period, especially the K- content highly decreased than zero- time samples and after the first cycle as well. K-fertilizer was not included in the fertilizer treatments since the beginning of the experiment.

Concerning the micronutrients(Zn, Fe and Mn), the available soil contents showed significant increases on DTPA-Zn content since the crop Rot.2

(wet wet) increased Zn by 42% over the crop Rot.1 (wet) and by 8% over the crop Rot.3 (dry). Worth to mention that DTPA-Fe- content and DTPA-Mn content were not affected by the application of crop rotation. However, Fe- content decreased and Mn-content increased compared with the contents of the zero- time samples.

2- Effect of application of different levels of N and P on soil fertility:

The obtained data in Table (4) indicated that the residual available N content was significantly increased by increasing all fertilizer application levels over the zero fertilizer level with no significant difference between the low and the medium levels.

It is worthy to mention that the available N content was low under the lower fertilizer levels (0, L and M) comparing with the zero- time samples, showing that these levels, were not sufficient for growing crops, especially the high yielding varieties, which remove more amounts of N. However the high fertilizer level (H) a showed slight increase over the initial N status (zero- time).

The data in Table (4) indicated also that residual available soil P content increased significantly with increasing N and P fertilizer levels up to the high level, however, the medium and high fertilizer levels showed superiority over the initial P status zero-time samples The data also indicated that no significant effect of fertilizer application on the available K- content in the soil. This could be attributed that El Serw location is characterized by the heavy clay soils with high K-content. Therefore, potassium fertilization was not included in this respect (5 and13). Concerning the organic matter content the fertilizer levels application showed no significant effects on it.

The data in Table (4) showed that the available Fe- content was slightly decreased with increasing N and P fertilizer level this may due to the high yielding crops remove more amounts of Fe. On the other hand, DTPA-Mn content recorded higher values than that zero- time samples after the first cycle. The same trend was bound by DTPA-Zn-available soil content since the Zn content was higher (1.26 ppm) than the Zn- content (0.80) of zero- time samples. The added N fertilizer showed the highest RC% for N (47%) followed by Zn (10.38%), while the added P fertilizer recorded the best RC% for p (69.05%) and Zn (22.99%) as shown in Table (6).

After the second cycle of the 3-year crop rotation, the application of NP fertilizer levels significantly increased the OM content up to high level (H) over the zero fertilizer level with no significant difference level between the low and the medium levels, since the high level (H) increased the OM content by 7%, and 5% over the zero-fertilizer treatment and over low and medium levels of NP respectively. The available soil N was also significantly increased by increasing NP levels up to the high level (H), also with no significant difference between low and medium fertilizer levels, since the addition of the high level of N recorded 35.9 ppm N, while the low and medium levels of NP recorded 33.3ppm N and the zero fertilizer treatment gave only 30.0ppm N. However, the available P and exchangeable K content showed no significant difference and lower content than the content after the first cycle and the initial content of zero- time samples. Concerning the available soil content of Zn, Fe and Mn, the data in Table (4) showed no significant differences due to the application of NP fertilizer levels, with slight decreases by increasing N and P fertilizer levels.

It is worthy to mention, that Fe- content decreased. This may be due to the salinity of drainage water, which reduces the Fe-availability and Mn and Zn contents were increased compared with the zero- time samples

3. Effect of irrigation water on soil fertility

The water quality did not show significant effects on the available N, P, K and OM content after the first cycle of the 3 years crop rotation, since the mineral N-content under irrigation with drainage water showed 41.4ppm compared with 31.6 ppm under irrigation with fresh water, while after the second cycle, irrigation with drainage water showed significant increase compared with irrigation with fresh water. This could be attributed to the leached NO_3 anions in the drainage water. Similar results were obtained previously by Selin (1998) and Kranss (2000), however, El Kholy (1993) noted that N- uptake by plants decreased as a result of the competition between chlorides in large amount existing in drainage water and the nitrate anions needed for plant growth. P, K and OM content under irrigation with fresh water showed significant increases reached to 15%, 4% and 5% over drainage irrigation respectively.

Concerning the micronutrients (Zn, Fe and Mn), the obtained results indicated (Table 5) that Zn and Mn contents did not significantly affected with water quality (fresh and drainage after the first and the second cycle of the 3 years crop rotation). However, the Fe content was significantly decreased under drainage irrigation water and the reduction reached 50% less than that of fresh water. This may be due to the high salinity and content of drainage water which reduces Fe availability.

Data in Table (6) indicated that water quality had the highest RC % for Fe (79.22%) followed by Mn (36. 54%), N (25.55%) and K (6.25%).

Table 4: Effect of different levels of N and P fertilizers on soil fertility builds up after 2- cycles of 3-year crop rotation at El Serw research station experimental farm.

Fertilizer level	O.M, %	Determined available nutrients, µgg^{-1}					
		Macronutrients			DTPA-micronutrients		
		N	P	K	Zn	Fe	Mn
First cycle							
Zero-time	1.72	39.8	18.8	629	0.80	15.8	6.27
0	1,93	27,7a	12,4a	673	1,26	11,8	14,5
Low	2,04	34,3b	16,2b	658	1,26	10,7	14,5
Medium	2,05	36,9b	19,7c	664	1,26	9,4	14,1
High	2,01	47,1c	23.6d	658	1,06	10,5	13,8
Second cycle							
0	1,70a	30,0a	11,1	588,0	1,26	11,6	14,5
Low	1,74b	33,3b	11,2	581,7	1,26	10,0	14,1
Medium	1,77b	32,3b	11,2	584,5	1,26	9,5	13,9
High	1,82c	35,9c	11,6	582,4	1,06	10,5	13,8

Table 5: Effect of irrigation water resources (Fresh and drainage) on soil fertility after 2 cycles of the 3 years crop rotation at El Serw research station experimental farm.

Crop rotation	First cycle		Second cycle	
Water Resource (WR) / OM & Av.Nut.	Fresh Water (FW)	Drainage water (DW)	Fresh Water (FW)	Drainage water (DW)
O.M, %	2,02	2,03	1,8 b	1,71 a
N, µgg^{-1}	31,6	41,4	31,1 a	34,6 b
P, µgg^{-1}	18,2	17,9	12,06	10,48 a
K, µgg^{-1}	672	655	595 b	574 a
Zn, µgg^{-1}	1,10	1,33	1,10	1,32
Fe, µgg^{-1}	14,05 b	7,02 a	13,98 b	6,83 a
Mn, µgg^{-1}	12,74	15,64	12,64	15,45

OM & Av. Nut.: Organic matter %, available macronutrients and DTPA-extractable micronutrients.

Table 6: Relative contribution (RC%) of studied treatments and factors for soil residuals after the first cycle of the 3- years crop rotation.

	Organic matter (OM) and available nutrients						
Treatments	O.M	N	P	K	Fe	Zn	Mn
Water quality	-	25.55	-	6.25	79.22	-	36.59
Crop rotation	24,76	7.43	21.24	-	-	-	5.38
Added N	-	47,00	-	1,57	1,85	10.38	-
Added P	-	-	69.05	-	-	22.99	-
Total	24.76	79.98	90.29	7.82	81.07	33.37	41.97

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الملخص العربى

استدامة خصوبة التربة بعد ٣ سنوات دورات محصولية فى محطة بحوث السرو شمال شرق الدلتا فى مصر

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أجريت تجربة طويلة الأمد فى شمال شرق مصر(محطة بحوث السرو) خلال ٦ سنوات لدراسة استدامة خصوبة التربة تحت ظروف ادارة مختلفة للموارد منها مثلاً: ٤ مستويات من التسميد النتروجينى والفوسفورى وهى (بدون، منخفض، متوسط وعالى)، جودة مياه الرى (مياه رى، مياه صرف زراعى) بالأضافة الى ٣ تعاقبات محصولية هى مبتلة(Rot1)، مبتلة مبتلة(Rot2)، جافة(Rot3). وأظهرت النتائج المتحصل عليها للدورتين المحصوليتين مايلى:

زاد معنوياً النتروجين المتيسر(N) والفوسفور المتبقى بزيادة معدلات اضافة اسمدة النتروجين والفوسفور وذلك بعد الدورة المحصولية الأولى، بينما لم يتأثر البوتاسيوم المتبادل. وبعد الدورة المحصولية الثانية زادت معنوياً كمية النتروجين المتبقى ومحتوى المادة العضوية مع زيادة معدلات التسميد، بينما لم يتأثر كل من الفوسفور(P)، البوتاسيوم(K). ادى استخدام مياه الصرف الزراعى فى الرى الى زيادة معنوية فى النتروجين المتبقى بنسبة ٣١%، ١١% بينما نقص الحديد ب ٥٠%، ٤٩% على الترتيب، بالمقارنة بأستخدام مياه الرى بعد الدورة المحصولية الأولى والثانية على الترتيب والتى استمرت كل منها ٣ سنوات. ايضاً حدث زيادة فى محتوى الزنك (Zn) والمنجنيز(Mn) بأضافة مياه الصرف عن مياه الرى. وقد أدى اتباع التعاقب المحصولى مبتلة مبتلة(Rot2) معنوياً الى زيادة تركيز الزنك والمنجنيز المتبقى بالمقارنة بالتعاقب المحصولى المبتل(Rot1) والتعاقب المحصولى الجاف (Rot3)، وربما يرجع ذلك الى ان المحصول الشتوى كان برسيم خلال ٣ سنوات بينما التعاقب المحصولى فى Rot3 الجافة سجل زيادة معنوية فى محتوى كل من الفوسفور والبوتاسيوم المتبقيان بالمقارنة بكل من التعاقب المحصولى فى الدورات١، ٢ (Rot2, Rot1). زاد تركيز الزنك المتبقى عند اتباع الدورة المبتلة المبتلة (Rot2) بالمقارنة بالدورة المبتلة والدورة الجافة، بينما لم يتأثر كل من المنجنيز والحديد المتبقيان بعد انتهاء التعاقبين المحصوليين. سجلت اضافة الأسمدة الأزوتية اعلى مساهمة نسبية فى النتروجين المتبقى (٤٧%)، تلاها الزنك ب ١٠.٣٨%، وكانت المساهمة بالنسبة للفوسفور المضاف ٦٩% فى الفوسفور المتبقى و٢٢.٩٩% للزنك المتبقى.