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WETLAND'S REVEGETATION IMPACT ON SOME SOIL PROPERTIS AT MANZALA REGION, EGYPT.

El-Nady, Manal A. and R.R. Shahin
Soil Science Department, Faculty of Agriculture, Cairo University, Giza, Egypt. *E-mail: dredashahin@gmail.com

ABSTRACT

This study was done on wetlands of Manzala Lake, northeastern Nile Delta of Egypt, to evaluate the changes of some soil properties after rehabilitation and cropping for 10 years. Soil samples (0-80 cm depth) were collected randomly from selected sites in 4 reference wetlands sites and 4 cultivated sites with rice and cotton. Soil properties showed marked variation across the soil profiles. The obtained results showed that cultivation significantly accounted for the variance in soil properties between reference and cultivated wetland. Bulk density (Bd), hydraulic conductivity (K) and the electric conductivity (EC) were decreased while; total porosity (Tp), available water capacity (AWC) and organic matter (OM) were increased under cultivated areas compared with the reference wetlands. A significant difference in most of these soil properties under both rice and cotton was found between cultivation periods. The results also show that soil properties varied according to the cultivated crop. This study indicated a trend toward progressive soil development following wetland revegetation. Development of wetlands should be done.
Keywords: wetlands, cultivation of wetlands, Manzala Lake, soil physical properties.

INTRODUCTION

Wetlands, defined by USDA-NRCS (1979) and USEPA (1980), are areas inundated or saturated by an accumulation of surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances, do support a prevalence of vegetation typically adapted for life in saturated soil conditions. The frequency and duration for a jurisdictional wetland identified by the U.S. Army Crops of Engineers (2002) is when the water table is within 30 cm of the soil surface for 5% or more of the growing season in at least half the year.

Expansion of human population is demanding more food which is a matter of great concern for policy makers in Egypt. So, rehabilitation and cropping of wetlands seemed may partially solve this problem. Manzala Lake was reduced to the half during the past 30 year's activities (saad, 1990). The dried areas were revegetated through numerous soil reclamation projects to increase food production in Egypt (FAO, 1993 and DRI, 1997). In addition, wetlands revegetation can act as a carbon reservoir and assists in reducing the amount of carbon dioxide in the atmosphere, decreasing the greenhouse effect and leading to a more stable climate (Karathanasis *et al.,*2003).

Revegetation of wetlands may induce major changes in soil properties. Several soil physical, chemical, and biological indicators have been proposed to assess changes in soil quality, including water-holding capacity, bulk density and total organic C (Doran and Parkin, 1994). Organic matter is the driving force behind many wetland functions; thus it is a frequent parameter used to assess hydric soil development (Campbell *at al.,* 2002). Cultivation of wetlands increases organic matter which lowered bulk density, increased hydraulic conductivity, infiltration capacity and water holding capacity and improves cation exchange (stanturf and Schoenholtz, 1998). In addition it supplies nutrients, such as N and P and maintains the structural stability of a soil by reducing wind and water erosion (Stauffer & Brooks, 1997).

This study was undertaken to investigate the major changes in wetland properties taking place before and after cultivation and to examine the impact of the crop type and cultivation period on wetland's physical properties.

MATERIALS AND METHODS

Study area

Experimental sites were conducted to evaluate changes in the main soil physical and chemical properties on natural sites and on cultivated sites by integrating two time sequences. Eight soil profiles were selected at El-Manzala, Dakahleya Governorate (Fig.1). The selected sites were intended to cover the dominant cultivation periods in the area as they divided into: (1) original wetland which included soil profiles 1, 2, 3 and 4 (2) wetland cultivated for five years, as represented by profiles Nos. 5 and 6 and (3) wetland cultivated for ten years, as represented by profiles Nos. 7and 8. The dominant summer crops in the region were rice, cotton.

Fig.(1): Locations of the profiles representing Manzala wetlands North-Eastern Nile Delta, Egypt.

Soil analysis

Soil samples were randomly collected from the 0- to 80-cm depth at each site. Samples were air dried and passed through a 2-mm sieve for EC, pH and particle size analysis. The former was determined in a 1:2 soil–water suspension and the latter by the pipette method (Gee and Bauder, 1986). The organic matter content was estimated by Walkley-Black (Nelson, and Sommers, 1982)). Soil physical properties: bulk density, hydraulic conductivity and Soil moisture characteristic were determined in undisturbed soil samples according to Klute (1986).

RESULTS AND DISCUSSION

Table (1) represents some physical and chemical properties of the investigated soil profiles.

Table (1): Some physical and chemical properties of the investigated soil profiles.

Profile No.	Depth (cm)	Cultivati-on period	Cultivated crops	Bd $g.cm^{-3}$	Tp (%)	Ksat (cm / h)	AWC (%)	EC dS/m	OM (%)	pH	Clay (%)	Tex. class
1	0-20	Zero	Non	1.55	47.34	16.39	7.01	32.60	0.55	7.79	0.94	Sand
	20-40			1.49	43.72	12.92	6.51	71.00	0.75	7.43	5.12	Sand
	40-60			1.36	46.92	8.57	9.70	113.70	3.25	7.69	61.45	Clay
	60-80			1.12	56.89	3.62	12.73	129.00	5.36	7.51	62.10	Clay
2	0-20			1.51	41.89	15.66	7.37	34.00	0.41	7.67	4.01	Sand
	20-40			1.54	43.75	6.97	7.86	88.00	0.64	7.77	8.92	Sand
	40-60			1.06	59.91	1.21	18.60	123.50	3.32	7.27	61.65	Clay
	60-80			1.16	55.68	1.10	17.98	123.80	1.60	7.25	59.65	Clay
3	0-20			1.23	53.93	14.16	10.37	330.00	2.83	7.01	36.58	C.l
	20-40			1.25	52.91	12.62	10.45	117.70	1.91	7.44	36.26	C.l
	40-60			1.34	49.46	5.97	9.74	131.00	0.70	7.24	25.41	Loam
	60-80			1.18	55.60	4.35	14.77	144.00	3.03	7.28	33.22	C.l
4	0-20			1.09	60.76	4.94	13.83	400.00	4.47	7.21	40.83	Clay
	20-40			1.22	56.42	3.98	12.47	153.00	2.87	7.42	59.36	Clay
	40-60			1.28	52.05	7.53	14.19	139.00	1.91	7.50	18.70	S.l
	60-80			1.47	45.95	14.69	8.46	140.00	0.64	7.53	3.60	Sand
5	0-20	5 yrs	Cotton	1.20	56.47	11.64	16.03	50.00	3.51	7.80	34.51	C.l
	20-40			1.21	54.63	8.57	15.74	37.70	3.41	7.77	35.40	C.l
	40-60			1.05	59.34	3.91	16.65	40.00	2.87	7.64	60.26	Clay
	60-80			1.14	57.54	2.34	16.44	45.30	2.87	7.44	58.16	Clay
6	0-20		Rice	1.06	57.81	1.22	15.48	15.70	3.31	7.79	39.26	C.l
	20-40			1.04	56.08	2.02	15.11	26.30	3.03	7.35	37.26	C.l
	40-60			1.01	60.67	0.49	16.26	34.00	2.87	7.60	41.22	Clay
	60-80			1.07	58.42	0.25	15.86	34.00	4.69	7.83	62.13	Clay
7	0-20	10 yrs	Rice	1.13	59.27	3.26	15.16	33.00	3.76	7.87	39.80	C.l
	20-40			0.83	64.38	3.06	14.72	44.50	3.13	7.64	60.72	Clay
	40-60			0.86	63.49	4.80	15.39	50.00	3.03	7.62	62.97	Clay
	60-80			1.08	60.91	13.2	14.17	60.00	1.34	7.45	55.68	Clay
8	0-20		Cotton	0.97	63.63	10.54	19.52	20.30	4.15	7.80	52.36	Clay
	20-40			1.05	58.97	8.94	18.57	24.00	3.71	7.62	36.15	C.l
	40-60			1.19	54.12	5.38	18.89	30.50	3.14	7.56	44.51	Clay
	60-80			1.24	56.96	1.02	18.53	43.70	3.86	7.80	46.43	Clay
L.S.D 0.05				0.056	1.406	1.164	0.889	1.508	0.459			
L.S.D 0.01				0.075	1.882	1.558	1.189	2.017	0.614			

C.l: clay loam, S.l: sandy loam

1. Effect of wetland cultivation on soil properties

In this study, soil profile No. (3) was taken to represent the reference wetland while, soil profiles Nos. (5 &6) and (7 &8) were taken to represent the cultivated wetlands for 5 and 10 years, respectively.

1.1. Soil pH

The pH level is generally around neutral. It is as low as 7.01 and as high as 7.87. It was indicated by Gosselink and Mitsch, (1986) that wetland soil tends to posses a pH that is near 7.0 or neutral. With cultivation the pH was slightly increased. However, still inside the range which is optimal for growth.

1.2. Soil salinity and organic matter

Soil salinity (EC) and organic matter (O.M) data given in Table (1) show a sharp decline in EC values occurred with cultivation compared to the reference wetland. Figure (2) also, revealed a sharp decrease in soil-EC with increasing the period of cultivation, yet the reduction was much higher under rice crop compared to cotton. Generally, soil-EC sharply decreased by depth in the initial wetland, while it gradually decreased by cropping due to the removal of most soluble salts by drainage.

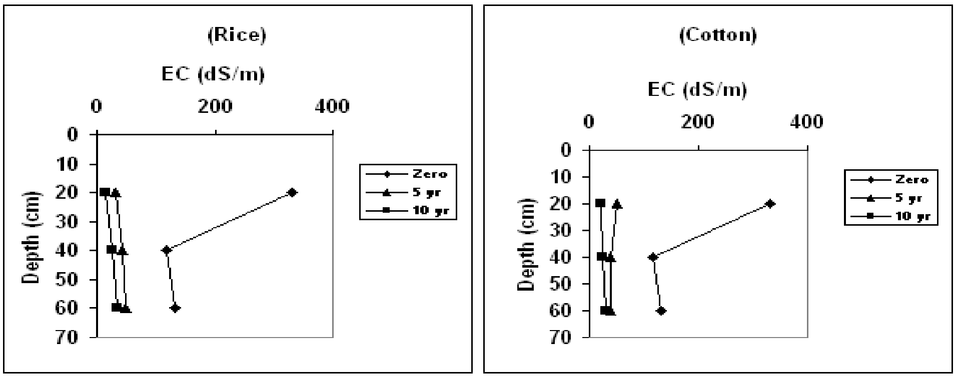


Fig.(2): Electrical conductivity (EC) of the studied profiles as affected by rice and cotton cultivation for 5 and 10 years.

Regarding organic matter, Fig.(3) showed that initial wetland had the lowest OM% and it was increased by increasing the cultivation period, which is in agreement with Baldwin (2008). The data also show that, cotton cultivation significantly increase OM% as compared to rice. This increase is due to its rapid decomposition in hydric soil conditions of rice fields. In addition, OM% follows the normal distribution in the investigated soil profiles as it decreased with increasing depth.

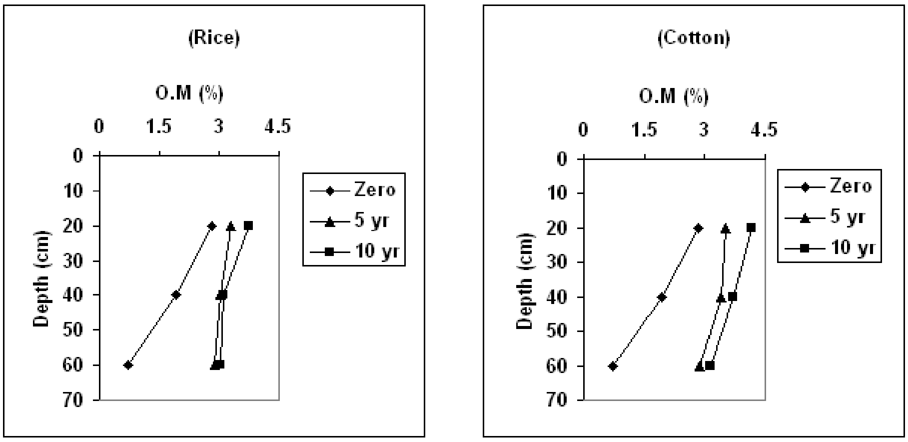


Fig.(3): Organic matter (OM) of the studied profiles as affected by rice and cotton cultivation for 5 and 10 years.

1.3. Bulk density (Bd) and Saturated hydraulic conductivity (K_{sat})

Bulk density values (Bd) are given in Table (1) and shown in Fig.(4). The data show that the variation in (Bd) values of the reference wetland is due to the variation in soil texture and to the presence of sea shells. Sea shells reduce the (Bd) values as compared to the layers without sea shells especially in the surface layers of wetland profiles. Also, Fig.(4) showed a remarkable decrease in (Bd) by increasing the cultivation period under both rice and cotton crops. Carroll and Robert, (2000) reported that higher OM % and lower Bd occurred in the vegetated areas of the wetland compared to the areas near the inflow and outflow streams. Nair *et al.,* (2001) also, found a direct relationship between organic carbon content and bulk density, showing that soils with ≤ 2.5 total carbon were more compact than soils with ≥2.5 % total carbon. Generally, the obtained values of (Bd) are not critical for plant growth according to Daniels and Whittecar, (2004) who reported that, root limiting bulk densities in soils range from 1.45 $Mg.m^{-3}$ for fine textures to 1.75 $Mg.m^{-3}$ for coarse loamy textures. The data also show that (Bd) values slightly increased by depth.

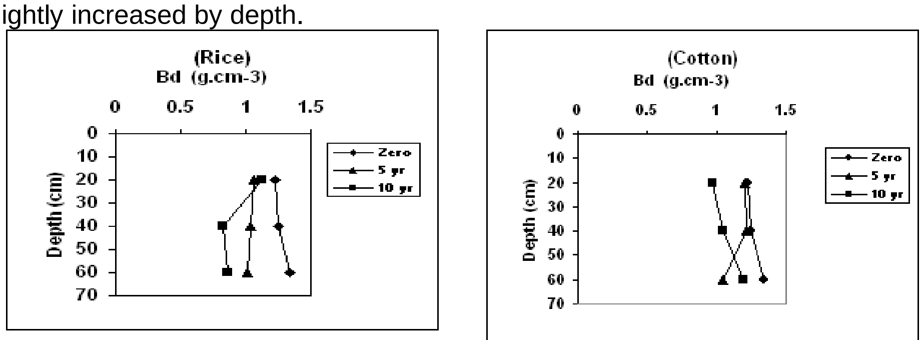


Fig.(4): Bulk density (Bd) of the studied profiles as affected by rice and cotton cultivation for 5 and 10 years.

Regarding the saturated hydraulic conductivity (K_{sat}), Table (1), the data show a significant variation in (K_{sat}) values according to the texture of the layer and to the effect of sea shells dominated in the studied profiles. (K_{sat}) values in the layers containing sea shells and its residual are higher than those layers without sea shells. Comparison between reference wetland and cultivated wetland, Fig.(5) showed a decline trend in (K_{sat}) values with cultivation for the different depths under both rice and cotton.

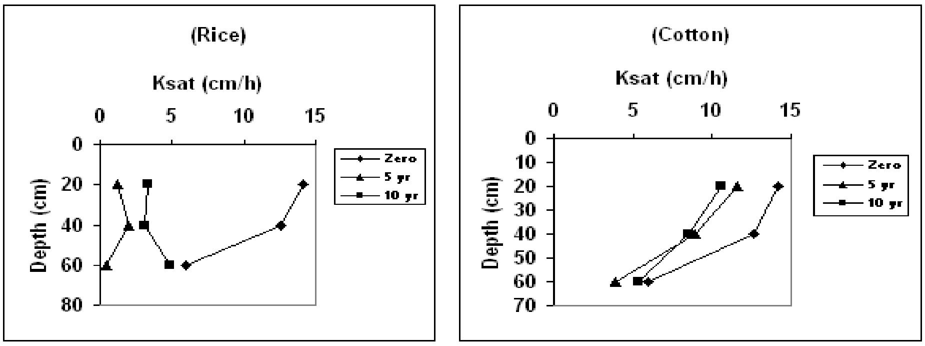
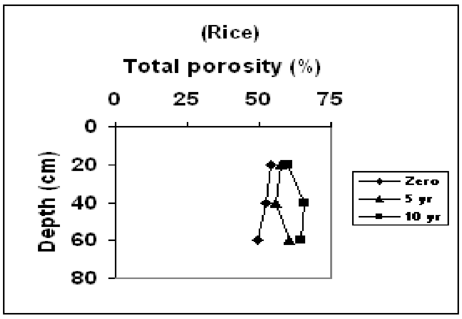


Fig.(5): Hydraulic conductivity (K_{sat}) of the studied profiles as affected by rice and cotton cultivation for 5 and 10 years.

However, (K_{sat}) values were higher under cotton crop than under rice. A significant difference in (K_{sat}) values between the reference wetland and cultivated wetland was found. In the present study the reduction of (K_{sat}) is due to the reduction in macro-pores (**>30µ)**) even the total porosity increased with increasing cultivation period. Miller and Donahue, (1995) indicated that macro-pores and fissures allow for relatively rapid flow of water through the soil profile.

1.4. Total porosity and pore size distribution

Data presented in Table (1) show that total porosity ranges between 66.0% and 38.0 %. The higher values were obtained with clayey layers that contain sea shells. Sandy and sandy loam layers have relatively low porosities. A trend of increasing total porosity values can be observed under cultivated wetland Fig. (6). The highest increase was recorded after 10 yrs comparing to 5 yrs of cultivation under both rice and cotton. A significant difference was found between reference wetland and cultivated areas and also between periods of cultivation.



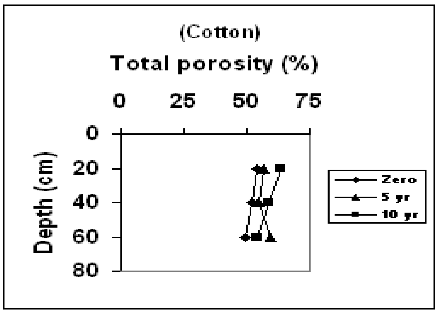


Fig.(6): Total porosity (Tp) of the studied profiles as affected by rice and cotton cultivation for 5 and 10 years.

The distribution of pores as affected by the cultivation period is presented in Table (2). An increase in quickly drainable pores (> 30μ) is recognizing in reference wetland compared to cultivated wetland. The slowly drainable pores (30-9μ), water holding pores (9-0.2μ) and fine capillary pores (< 0.2μ) increased with cultivation as compared to reference wetland.

Table (2): Effect of cultivation periods on pores distribution.

Soil depth (cm)	Reference	Rice		Cotton	
	Cultivation periods				
	zero	5 yr	10 yr	5 yr	10 yr
	Quickly drainable pores (> 30 μ)				
0-20	40.39	22.40	27.95	26.37	25.35
20-40	39.73	23.89	34.57	26.84	24.03
40-60	38.90	24.23	36.22	25.08	23.21
	Slowly drainable pores (30-9 μ)				
0-20	3.01	3.34	3.65	5.19	4.73
20-40	3.61	5.15	3.81	5.22	5.95
40-60	3.46	3.87	2.87	3.79	3.68
	Water holding pores (9-0.2 μ)				
0-20	20.75	26.78	25.30	28.39	30.68
20-40	19.75	24.09	22.45	28.81	31.49
40-60	21.31	24.58	25.83	26.44	32.15
	Fine capillary pores (<0.2 μ)				
0-20	35.85	47.48	43.10	40.05	39.24
20-40	36.91	46.87	39.17	39.13	38.53
40-60	36.33	47.32	44.79	44.69	40.75

3.1.5. Soil moisture characteristic curves

The volumetric water content versus pressure was plotted for the studied soil profiles, Fig. (7). The figures show that there are differences in both shape and magnitude of the soil moisture characteristic curves from one profile to another. The changes in shape and magnitude of reference wetland profiles are mainly due to the continuous saturation by water and to the effect of sea shells that spread in these soils. Sand fraction and sea shells spread in these profiles facilitate the release of water and relatively increased the released water. In cultivated wetland, a gradual decrease in moisture content under the applied suctions was recognized. This may be due to the regular distribution of pores of these soils. Continuous cultivation changed the soil water retention capacity since the pore system is disrupted.

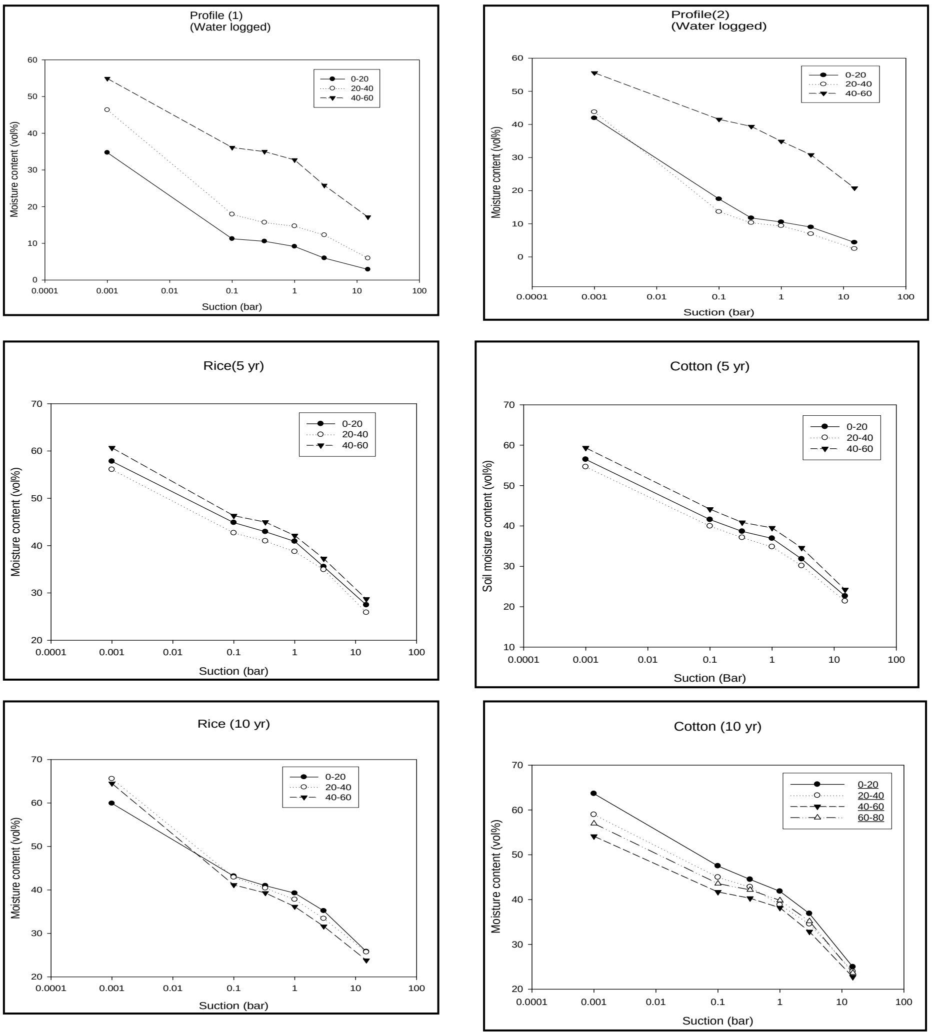


Fig.(7): Moisture characteristics curves of the native wetlands profiles (1 and 2) close to Manzala Lake and those cultivated with rice and cotton.

1.6. Available water capacity (AWC)

Available water capacity for each layer were calculated and given in Table (1). The data show that cultivation significantly increased the (AWC) compared to the reference wetland, Fig. (8). Increasing (AWC) of the cultivated wetlands is due to the increase in OM content and to the decrease in soil salinity. This is in agreement with the Natural Resources Conservation Service, (2002) who stated that increasing soil salinity decrease available water and that will have a negative effect on crop yield. The (AWC) values obtained under cotton were higher than rice. There was a significant difference in (AWC) values between the cultivation periods only under cotton.

The relationships between the (AWC) and each of bulk density and total porosity were fitted using best fitting equation. The cubic polynomial function gives the higher correlation compared to the other equations.

a- relation between (AWC) (y) and (Bd) (x):

$y= -84.52+239.90x-178.30x^2+39.90x^3$ $R^2= 0.643$

b- relation between (AWC) (y) and (Tp) (x):

$y= -11.29-0.065x+0.021x^2-0.0002x^3$ $R^2= 0.641$

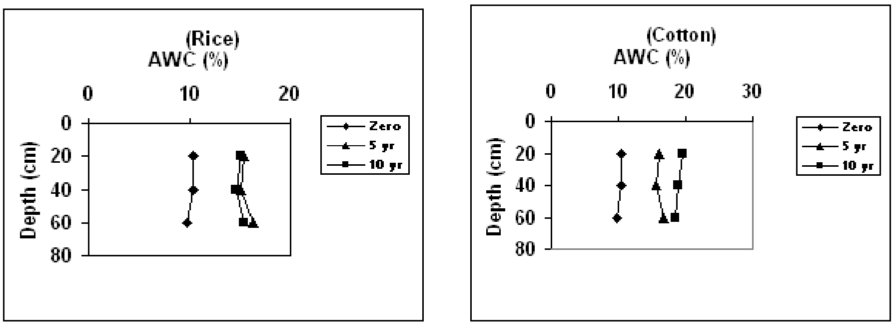


Fig.(8):Available water capacity (AWC) of the studied profiles as affected by rice and cotton cultivation for 5 and 10 years.

CONCLUSION

Variation in soil physical and chemical properties were recorded between reference wetland and cultivated wetland. Changes in these soil properties are due to cultivation of these lands. Cultivation promoted significant reduction on bulk density, hydraulic conductivity and EC. Whereas, an increase pattern is consistent with total porosity, available water capacity and soil organic matter content. Cultivation practices cause greater or lesser changes in these soil properties. The cultivation period also affected these properties. Increasing years of cultivation resulted in an increase of total porosity, available water capacity and OM. There was a significant difference between cultivated and reference wetlands and also between cultivated periods for 5 and 10 yr. These results confirm that conversion of natural wetlands through cultivation resulted in enhancement of soil physical and chemical properties.

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تأثير أعادة زراعة الأراضى الغدقة فى منطقة المنزلة على بعض خواص التربة

منال أبو المعاطى النادى و رضا رجب شاهين
قسم الأراضى-كلية الزراعة-جامعة القاهرة

أجريت هذة التجربة فى منطقة الاراضى الغدقة لبحيرة المنزلة شمال دلتا النيل فى مصر و ذلك لتتقييم التغيرات الحادثة فى بعض الجواص الطبيعية بعد فترات زراعة مدتها خمس و عشر سنوات و مقارنتها بالاراضى الغدقة الغير مزروعة. أخذت عينات التربة عشوائيا من أعماق صفر إلى ٨٠ سم من أربعة مواقع تمثل الأراضى الغدقة الغير مزروعة و من ستة مواقع تمثل الأراضى الغدقة بعد تجفيفها و زراعتها بمحصولى الأرز و القطن. أظهرت النتائج المتحصل عليها أن زراعة الأراضى الغدقة قد أثرت معنويا على خواص التربة و قد حدث تغير معنوى فى هذة الخواص بزيادة فترات الأستزراع. حيث قلت قيم الكثافة الظاهرية و التوصيل الهيدروليكى و كذلك قيم التوصيل الكهربى بينما زادت قيم المسامية الكلية و الماء الميسر و كمية المادة العضوية و ذلك فى الأراضى المزروعة عند مقارنتها بالأراضى غير المزروعة. بينت النتائج ايضا أن خواص التربة المدروسة قد أختلفت تبعا للمحصول المنزرع. هذة الدراسة تؤكد الأتجاة ناحية تطور هذة الأراضى و تحسن خواصها بالاستمرار فى زراعتها.