J. Agric. Sci. Mansoura Univ., 28(10): 7447 - 7454, 2003

SOME BIOLOGICAL ACTIVITIES UNDER TILE DRAINAGE COMPARED TO SURFACE DRAINAGE

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ABSTRACT

Agricultural lands in upper Egypt had been brought under perennial irrigation after the construction of Aswan High Dam (1960-1968). The natural drainage system that had sustained permanent agriculture for millennium could no longer cope with increased percolation from irrigation, and large areas had become waterlogged and salinized. An area of 2.21 million feddans in the Nile Delta was provided with tile drainage at the end of 1998.

Fifteen soil profiles were chosen from five regions of alluvial soils. They mainly differed in the age of implemented tile drainage network at El-Minofiya and Kafr El-Sheikh Governorates, representing both middle and north Delta soils. In each region, three profiles were selected where the first the profile is surface drainage, the second is beside the lateral and the third profile is located just in the midway between.

The relation between the microbiological activities (total bacterial counts, dehydrogenase and nitrogenase activities) and the prevailed drainage conditions had been studied.

The results showed that the biological activity has been pronounced in the old tile drainage specially the total bacterial count. In the newly tile drainage (Sidi-Salim region I) and (Sidi-Salim region II), the bacterial count in the surface drainage soil was higher than that of the tile drainage. The high values of dehydrogenase activity were recorded in Mahalat Alkassab region profile 3P2 (beside the lateral). The nitrogenase activity mostly decreased with increasing soil depth.

Total nitrogen in soil profiles, decreased gradually with depth. The highest value of total nitrogen (0.53%) was found in profile 1P2.

Keywords: Soil profiles depth, tile drainage systems, and biological activities.

INTRODUCTION

In general, the objectives of agricultural drainage system are: reclaim and conserve land for agriculture, increase crop yields, permit the cultivation of more valuable crops, allow the cultivation of more than one crop a year, and/or reduce the costs of crop production (Oosterbaan, 1994). Naguib (1987) found that, soil physical properties had been improved after tile drainage installation where soil aeration, trainable porosity, and hydraulic conductivity increased progressively, but bulk density decreased. Freeman *et al.* (1996) examined the microbial activity and enzymatic decomposition during a field-based experimental lowering of the water table in a peat land. Effect of soil drainage on quantity and quality of microbial populations of melon and maize rhizosphere were investigated. The numbers of bacteria especial Fluorescent pseudomonads in the rhizosphere were higher when plants were grown in more compacted soil and the relative increase was larger in Fluorescent pseudomonads. Abdel-Mawgood (1987) concluded that

the installation of tile drains is considered one of the important factors affecting soil aggregate formation directly and indirectly.

The aim of the current study was to determine the biological activities change related to execute tile drainage system of different applicable periods in the Nile Delta soils compared with the profile of surface drainage.

MATERIALS AND METHODS

Fifteen soil profiles were chosen from five regions of alluvial soils at El-Minofiya and Kafr El-Sheikh Governorates, representing both middle and north Delta soils. They mainly differed in the age of implemented tile drainage network. In each region, three profiles were selected, the first profile is surface drainage, the second is beside the lateral and the third profile is located just in the midway between. The third profile was chosen as a reference to monitor the impact of tile drainage on soil properties under the same conditions (Table, 1). Soil water table levels were ranged between 95 cm in 1P1 and 160 cm in 2P3 (Table, 1). Electrical conductivity of the soil saturation extract was measured according to Jackson (1967). Soil pH was determined (1: 2.5) soil: water suspension according to Cottenie *et al.* (1982). Organic matter content was estimated by modified Walkly and Black method, (Jackson, 1967). Soluble cations and anions were measured in saturation extract (Richards, 1954). Total carbonate was determined by Collin's Calcimeter method, (Klute, 1986). Total bacteria in soil were enumerated using the dilution pour plate technique (Wollum, 1982). Dehydrogenase activity (DHA) was estimated according to Thalmann (1967). Nitrogenase activity assayed using GLC, model HP6980 according to the method described by Schollhorn and Burris (1967). The physico-chemical properties of soil samples tested are presented in Table (2).

Table (1): Location of the studied profiles, drainage type and age and soil water table levels.

Governorate	Location	Profile No.	Drainage type and age	Soil water table levels
El-Minofiya	Shibin El-Kom	1 (1P1, 1P2 and 1P3)	1P1: Surface 1P2: Beside the lateral, 33 years 1P3: In the midway between two laterals	1P1: 95 cm 1P2: 125 cm 1P3: 150 cm
Kafr El-Sheikh	El-Qarada	2 (2P1, 2P2 and 3P3)	2P1: Surface 2P2: Beside the lateral, 25 years 2P3: In the midway between two laterals	2P1: 130 cm 2P2: 138 cm 2P3: 160 cm
Kafr El-Sheikh	Mahalt Alkassab	3 (3P1, 3P2 and 3P3)	3P1: Surface 3P2: Beside the lateral, 16 years 3P3: In the midway between the lateral	3P1: 120 cm 3P2: 98 cm 3P3: 100 cm
Kafr El-Sheikh	Sidi-Salim1	4 (4P1, 4P2 and 4P3)	4P1: Surface 4P2: Beside the lateral, 9 years 4P3: In the midway between the lateral	4P1: 98 cm 4P2: 130 cm 4P3: 110 cm
Kafr El-Sheikh	Sidi-Salim 2	5 (5P1, 5P2 and 5P3)	5P1: Surface 5P2: Beside the lateral, 2 years 5P3: In the midway between the lateral	5P1: 125 cm 5P2: 142 cm 5P3: 140 cm

Table (2): Some physical and chemical properties of the tested soil profiles (average).

Profile No.	Age of drains (years)	EC dSm^{-1}	pH	TSS meq/L	SAR	OM %	$CaCO_3$ %	Texture
Monshaat-Esame Shibin El-Kom, El-Minofiya								
1P1	Surface drainage	2.60	8.51	26.0	5.51	1.11	3.06	Silty clay
1P2	Beside the lateral 33	0.99	8.60	9.9	1.92	0.92	3.33	Silty loam
1P3	Between two laterals 33	1.10	8.66	11.0	1.61	0.86	3.11	Silty loam
El-Qarada Kafr El-Sheikh								
2P1	Surface drainage	3.39	8.44	33.93	5.79	0.87	4.19	Silty clay
2P2	Beside the lateral 25	4.29	8.36	42.85	6.68	0.87	2.64	Silty clay
2P3	Between the laterals 25	2.67	8.61	26.70	3.66	0.71	4.10	Clay
Mahalat Alkassab-Kafr El-Sheikh								
3P1	Surface drainage	2.60	8.42	25.97	4.65	0.84	3.14	Silty clay
3P2	Beside the lateral 16	1.55	8.77	15.50	3.49	0.95	3.15	Silty clay
3P3	Between the laterals 16	1.28	8.48	12.77	2.83	1.02	2.96	Silty clay
Almasharka Sidi-Salim Kafr El-Sheikh (1)								
4P1	Surface drainage	3.74	8.53	37.40	6.54	1.03	2.04	Clay
4P2	Beside the lateral 9	2.52	8.47	25.23	5.55	0.89	2.60	Clay
4P3	Between the laterals 9	4.82	8.47	48.18	11.40	0.96	3.78	Clay
Almasharka Sidi-Salim Kafr El-Sheikh (2)								
5P1	Surface drainage	2.50	8.34	25.0	2.08	0.60	3.32	Silty clay
5P2	Beside the lateral 2	2.65	8.61	26.45	3.64	0.70	2.38	Clay
5P3	Between the laterals 2	1.96	8.80	19.55	4.00	0.56	2.79	Silty clay

Sodium adsorption-ratio: In soil extract: **(Richards, 1954).**

$$\frac{Na^{+}}{\sqrt{\frac{(Ca^{++}+Mg^{++})}{2}}}$$

RESULTS AND DISCUSSION

In Shibin El-Kom region, soil profile, provided with tile drainage (1P2 and 1P3), data in Table (3) indicate that total bacterial counts of profile 1P2 and 1P3 were 11.75 x 10^6 and 13.25 x 10^6 cfu/g, respectively, in comparison to 9.25 x 10^6 for the profile 1P1 (with surface drainage). Dehydrogenase activity (Table 3) exhibited the same trend as total count of bacteria; this may be due to improvement of aeration, physical and chemical characteristics of soils of profiles 1P2 and 1P3. The nitrogenase activity ranged from 0.0 n layer (90-120 cm) in profile 1P2 to (7.91 mmoles C_2H_4/100 g soil/day) layer (0-30 cm) in profile 1P1. There was no variation between the different profiles in total nitrogen % values.

Regarding the total count of bacteria, DHA and nitrogenase activities in the different depths of each profile, data in Table (3) show that there were no detectable variations among the examined profiles. But nitrogenase activity mostly decreased with increasing depth.

In El-Qarada, Kafr El-Sheikh region, it was found that profile 2P2 (beside the lateral) scored the highest bacterial count (17.28 x 10^6 cfu/g) followed by profile 2P1 (21.0 x 10^6) then profile 2P3 (16.0 x 10^6). While, profile 2P2 was the superior in dehydrogenase activity (83.20 ug TPF/g/day) followed by profile 2P1 (53.0 ug TPF/g/day) and profile (2P3) (33.20 ug TPF/g/day). Nitrogenase activity attained the same trend of dehydrogenase.

In the case of total nitrogen %, it was noticed that profile 2P2 attained the highest value, then profile 2P1, and eventually profile 2P3.

Table (3): Dehydrogenase and nitrogenase activities; total microbial counts and total nitrogen % in tested soil profiles as affected by the period of tile drainage system.

Prof. No.	Depth in cm.	Tile drainage period (year)	Total bacterial counts cfu/g soil x 10^6	Dehydrogenase activity, µg TPF/g/day	Nitrogenase activity, mmoles C_2H_4/100 g/day	Total nitrogen %
Monshaat Esame-Shibin El-Kom Minofiya						
1P.1	0-30	Surface drainage	10	0.72	7.91	0.55
	30-60		7	3.69	0.11	0.56
	60-90		8	7.92	0.18	0.55
	90-120		12	23.40	0.03	0.34
1P.2	0-30	Beside the lateral 33	7	89.90	0.26	0.49
	30-60		17	-	0.15	0.95
	60-90		11	28.70	0.05	0.39
	90-140		12	-	-	0.31
1P.3	0-30	Between the laterals 33	12	47.90	0.35	0.49
	30-60		10	28.29	0.36	0.43
	60-90		17	-	0.13	0.49
	90-140		14	65.16	3.87	0.49
El-Qarada Kafr El-Sheikh						
2P.1	0-30	Surface drainage	18	53.00	0.53	0.55
	30-60		18	00.33	0.30	0.32
	60-90		21	2.46	1.28	0.35
	90-140		6	1.38	2.04	0.43
2P.2	0-30	Beside the lateral 25	28	2.31	16.24	0.42
	30-60		19	15.54	0.34	0.55
	60-90		17	83.20	0.41	0.43
	90-110		5	6.78	1.31	0.35
2P.3	0-30	Between the laterals 25	16	33.20	7.59	0.38
	30-60		15	26.67	1.43	0.38
	60-90		12	14.76	1.13	0.34
	90-120		15	1.41	0.15	0.21

TPF = Tetrazolium phenyl formazin

Comparing different depths throughout each profile, data in (Table 3) indicated that a sharp decrease in total count of bacteria with depth was observed with profiles 2P1 and 2P2. No differences were observed in profile 2P3. On the other hand, decreases in dehydrogenase and nitrogenase activities were obtained with increasing the profile depth (Table 3). Generally, profile 2P2 (beside the lateral) showed that the increase of aeration led to improvement of physical and chemical properties of soil. Low aeration with increasing soil depth resulted in low microbial numbers and activity. These findings agreed with Alexander (1977) and Struz *et al.* (1997). The data also showed that there was no significant variation in the total nitrogen % between all the profiles.

In Mahalt Al-Kassab Kafr El-Sheikh region, data in Table (3) reveal that profile 3P3 exhibited high bacterial numbers when compared to the profiles 3P1 (surface drainage) and 3P2 (beside the lateral) whereas, the later showed low bacterial numbers. The data also showed the lowest value

of dehydrogenase activity was noticed in profile 3P3 (in the midway between the laterals), where the value was 116.10 ug TPF/g/day (3P2) layer (30-60). While, that values for profiles 3P1 and 3P3 were 65.16 layer (0-40) and 41.37 ug TPF/g/day layer (0-30 cm), respectively. The data in Table (3) also reveal that nitrogenase activity of the surface drainage 3P1 had a high value of nitrogenase activity compared to the values under the tile drainage profiles 3P2 and 3P3. The data of total nitrogen % showed no variation between the three profiles. However, the 3P2 profile was slightly higher than the others. This consistency in results may due to distfunction of tile drainage in some locations, the variation in soil water table levels and variation in soil types.

Table (3): Continue.

Prof. No.	Depth in cm.	Tile drainage period (year)	Total bacterial counts cfu/g soil x 10^6	Dehydrogenase activity, µg TPF/g/day	Nitrogenase activity, mmoles C_2H_4/100 g/day	Total nitrogen %
Mahalat Al-Kassab Kafr El-Sheikh						
3P.1	0-40	Surface drainage	4	65.16	9.19	0.29
	40-80		11	6.63	1.61	0.38
	80-120		15	31.20	2.43	0.39
3P.2	0-30	Beside the lateral 16	2	51.48	1.79	0.63
	30-60		11	116.10	0.35	0.31
	60-100		4	92.91	-	0.49
3P.3	0-30	Between the laterals 33	16	41.37	3.78	0.38
	30-60		15	30.00	0.63	0 39
	60-100		15	00.90	0.11	0.29
Almasharka Sidi-Salim Kafr El-Sheikh (1)						
4P.1	0-25	Surface drainage	42	42.90	4.76	0.48
	25-55		52	16.50	5.19	0.29
	55-85		32	6.24	0.56	0.32
	85-125		24	12.90	0.67	0.36
4P.2	0-45	Beside the lateral 9	15	5.25	NF	0.45
	45-82		14	2.64	0.42	0.29
	82-122		23	33.20	NF	0.21
	122-162		16	5.76	NF	0.18
4P.3	0-30	Between the laterals 9	16	4.95	15.20	0.43
	30-70		25	3.45	2.17	0.34
	70-110		17	7.71	1.31	0.29
	110-160		27	1.26	0.06	0.15
Almasharka Sidi-Salim Kafr El-Sheikh (2)						
5P.1	0-30	Surface drainage	19	11.61	0.32	0.28
	30-60		39	160.20	0.32	0.34
	60-90		19	2.07	0.25	0.28
	90-140		17	0.88	1.15	0.22
5P.2	0-30	Beside the lateral 2	14	74.10	0.59	0.36
	30-90		3	82.30	0.16	0.35
	60-90		6	41.50	0.05	0.52
	90-140		10	3.40	4.68	0.80
5P.3	0-30	Between the laterals 2	11	3.03	0.70	0.46
	30-60		10	9.42	-	0.24
	60-90		4	5.71	0.10	0.27
	90-140		7	3.60	0.52	0.28

In the case of profile 3P2, the second depth was higher in total bacterial count as well as DHA followed by third depth. While surface layer

(0-40 cm) was the best in nitrogenase activity and nitrogen content, this may be due to the majority of nitrogen fixing microorganisms are microaerophilic and mostly inhabit the surface layer. In the midway between the laterals profile 3P3 there was a consistent descending trend with increasing depth for total counts of bacteria, as well as DHA and nitrogenase activities and nitrogen content.

In Sidi-Salim Kafr El-Sheikh region (4P1, 4P2 and 4P3), data presented in Table (3) indicate that surface drainage of profile 4P1 attained higher values in total bacterial count, DHA, and total nitrogen than the other two profiles (4P2 and 4P3), while there was no clear difference in the case of nitrogenase activity. The surface layers of profile 4P1 was cultivated with clover plant, which may help in improving the microbial biomass and activity. Total count and dehydrogenase activity did not reveal a noticeable variation between different depths, while nitrogenase activity and nitrogen content generally decreased with increasing profile depth.

In Sidi-Salim Kafr El-Sheikh region profiles (5P1, 5P2 and 5P3), comparing average values of each profile, data in Table (3) reveal that soil with surface drainage (profile 5P1) and that located beside the lateral (profile 5P2), generally attained the better values of total count of bacteria, DHA, nitrogenase activity and total nitrogen. While, the tile drainage between the laterals attained the lowest values. This may be due to water logging of soil, which lead to deterioration of soil biotic characteristics. The forecited trend agreed with Garcia *et al.* (1994).

Regarding different depths, there was no variation between depths in all microbial parameters as well as total nitrogen. The tile drainage in this region is recently installed, so that the balance in microbial distribution through the profile has not established yet.

Data in Table (2) show that the mean values of organic matter of the studied soil profiles in Shibin El-Kom region ranged from 1.11% in profile 1P1 to 0.92% in profile 1P2, while it was 0.86% in profile 1P3 in the midway between the two laterals. The relative decrease of mean values of organic matter content under the condition of tile drainage (profiles 1P2 and 1P3) could be attributed to improving the oxidation conditions. In El-Qarada region, the mean values of organic matter ranged was 0.87% for both 2P1 and 2P2, while it was 0.71% in profile 2P3. In Mahalt Al-Kassab region, the mean values of organic matter ranged between 0.84% in profile 3P1, to 0.95% in profile 3P2, while it was 1.02% in profile 3P3. The variation of the O.M content in this region could be attributed to the crop pattern and the agricultural practices adopted by the local farmers. In Sidi-Salim region (1), the mean values of organic matter ranged from 1.03% in profile 4P1 to 0.89% of profile 4P2, while it was 0.96% of profile 4P3. In Sidi-Salim region (2), the mean values of organic matter ranged between 0.60% in profile 5P1 to 0.70% in 5P2 to 0.70% in 5P2 while, it was 0.56% in profile 5P3. In general, the organic matter percent showed a sharp decrease with increasing soil depth. The maximum values of organic matter were determined in the soil surface layers where the residual effect of cultivated crops and agricultural practices are intensed. In most of the studied profiles the O.M content was generally lower under the tile drainage system than the surface one.

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بعض الانشطة البيولوجية للصرف المغطى مقارنة بالصرف الصحى

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أصبحت الاراضى الزراعية فى مصر تروى بالرى الدائم بعد بناء السد العالى (١٩٦٠-١٩٦٨). تم تدعيم نظام الصرف الطبيعى للزراعة المستديمة ونتيجة الرى المستمر اصبحت هناك مساحات شاسعة غدقه وذات ملوحة عالية وأنشئ صرف مغطى لمساحة ٠٢,٢ مليون فدان فى الوادى بنهاية ١٩٩٨.

اختيرت خمسة عشر قطاعا ارضيا من خمسة مواقع للاراضى الرسوبية التى تختلف فى عمر انشاء شبكة الصرف فى محافظتى المنوفية وكفرالشيخ وهى تمثل كل من وسط وشمال الدلتا. اختير قطاعين من كل موقع فى الحقل ذو الصرف المغطى المناسب أحدهم يقع اقرب من الوسط بين الجانبين واختير القطاع الثالث فى حقل بدون صرف مغطى.

الهدف من الدراسة هو تقدير التغيرات البيولوجية المتعلقة بنظام الصرف المغطى فى مختلف الاعماق للقطاعات الارضية فى اراضى الدلتا. ودرست العلاقة بين الانشطة البيولوجيه (العدد الكلى للبكتريا وانزيمات الديهيدروجينيز والنتيروجينيز) مع ظروف نظم الصرف المختلفة.

وأظهرت النتائج أن هناك زيادة ملحوظة فى النشاط البيولوجى وخاصة فى شبكة الصرف المغطى القديمة وخاصة فى أعداد البكتريا الكلية وفى الشبكة الحديثة (منطقة سيدى سالم الاولى والثانية) كانت الاعداد البكتيرية فى الصرف السطحى اعلى منها فى الصرف المغطى.

اظهرت قيم نشاط انزيم الديهيدروجينيز نشاطا اعلى فى منطقة محلة القصب القطاع رقم ٢ بجانب الحقل عن الاخرين وكذلك لوحظ أن نشاط انزيم النيتروجينيز تناقص مع زيادة العمق.

تناقصت نسبة الازوت الكلى فى التربة بزيادة العمق فى القطاعات التى تم دراستها وكانت اعلى قيمة (٠,٥٣%) فى القطاع رقم (1P2).