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FERTILITY EVALUATION OF MINUFIYA GOVERNORATE SOILS AS AFFECTED BY TILE DRAINAGE SYSTEM

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ABSTRACT: *The present work was carried out to study influence of the tile drainage system and its reinstallation on soil fertility in El-Khadrawyia 1 area, in Minufiya Governorate with heavy clay soil. Where this area was served by reinstallation of tile drainage system in 1999.Soil samples were taken above and between drains at five distances of drain length: before drain and at 25, 50, 75 and 100 % of drain longitude. At the same distances, above and between drains, soil samples were taken at depths of 0-15, 15-30, 30-60 and >60 cm. Evaluation includes determination some soil physical and chemical properties and content of available N, P, K, Fe, Mn, Zn, and Cu, and its distribution in the soil.*

The results indicated that, Soil EC, TSS, pH, ESP increased with soil depth, and decreased along the lateral distance (25-130 m). Also, such decrease was clear above drains especially in the surface layer compared with that one occurred between the drains and in the down layers of soil profile. The soil content of available N between drains was higher than that found above the drains. Also, above and between drains, the content of N was decreased with extending the distance on the lateral length. The highest content of NO_3-N and P was found at the soil depth 15-30 or 30-60 cm, while the lowest content was found at the deeper layer. Available P and K between drains were higher than that found above the drains. Also, above and between drains, the content of P and K was decreased with extending the distance on the lateral length. The content of available micronutrients take the same trend for N and P. Were, the arrangement of these micronutrients according to their content were Fe > Cu >Mn> Zn in the soils of El-Khadrawyia 1.

Key words: *Minufiya Governorate, Tile drainage, Soil fertility, Soil properties and Nutrients availability.*

INTRODUCTION

Drainage of agriculture land is defined as the removal of excess surface and subsurface water from the soil as well as soluble salts in order to enhance the vegetative growth (ICID, 1979). Drainage plays an important role as a tool for controlling water table level, maintaining and improving crop yields as follows:-

- It prevents deterioration in the productivity of arable land as a result of raising water table and accumulation of salts in the root zone.
- A large portion of the land that is currently not being cultivated affected by water logging and salinity, drainage is the only way to reclaim such land (Bos and Boers, 1990). Tomer *et al.* (2003) reported that tile drainage, which is common agricultural practice to improve moisture and aeration conditions especially in lowland areas, shortens the residence time of water in the soil and is therefore an important pathway for nutrients-particularly nitrate and other contaminants such as pesticides into adjacent water bodies.

Hamid *et al.*(2013) studied micronutrients losses with tile drainage. Drainage waters were periodically analyzed for selected micronutrients, and reported that, the concentration of micronutrients generally changed with sampling time, this concentration was increased with soil depth and were invariably negative in nutrient balance sheet suggesting that these nutrients are continuously depleting from the system in drainage water. These nutrients therefore must be replenished in soil through appropriate means for optimum crop yields under the given drainage- irrigation-cropping system.

MATERIALS AND METHODS

Field experiment was conducted at El – Khadrawyia 1 area, with heavy clay soil in Minufiya Governorate, Egypt. The experimental area was served by reinstallation tile drainage system in 1999.The tile drainage system was carried out at 30 m drainage space and 140 cm depth. The average length of drain lines is approximately 130 m. Disturbed and undisturbed soil samples were taken above and between drains at five distances of drains longitude (before drain and at 25, 50, 75 and 100 % of drain longitude). At the same distance above and between drains, disturbed soil samples were taken at depths of 0-15, 15-30, 30-60 and >60 cm. The soil samples were air – dried ground and sieved through a 2 mm sieve and analyzed for some physical and chemical properties and its content of available macro-micronutrients using the methods described by; Page *et al*. (1982) and Klute (1986). Relative changes (RC) for the obtained data as a percentage (%) of control data were calculated using the following equation:

$$RC = \frac{\text{Mean value of b - mean values of a}}{\text{Mean value of a}} \times 100$$

Where: a= Profile located before the beginning of lateral, and
b = Profile located in the drained soil

RESULTS AND DISCUSSION
Soil Chemical Properties.
Soil Salinity.

Data in Table (1) show that the salinity of the tested soil represented by EC, soluble ions, TSS and SAR, generally increased with the depth of the soil profile. This may be attributed to leaching the amount of soluble salts with the irrigation water from the surface layer to the deeper one. The obtained data appeared an obvious decrease in soil salinity along the lateral distance (25-130 m). Wherever the relative decrease was ranged from 34-51, 35-51 and from 10-72 % for EC, TSS and SAR respectively compared with its one before lateral. Likewise a noticeable reduction were induced in soluble cations and anions. While the most cations and anions were affected by the lateral distance are Na^+ and Cl^-. This may be ascribed to the dominance of these ions in saline soils. In general, salinity parameter between the lateral demonstrated the same trend of that one above lateral. However, almost, the values of EC, TSS and SAR above the lateral were lower than those found between the lateral. That may be due to the greater amount of leaching water above the lateral compared with that one in the midway of the lateral. The facts which ought to mention herein that the abovementioned parameters were decreased by more than 50 % at the end of the lateral (near the collector drain) compared with that one before the lateral. In this respect Bol'shakov *et al* (1996), Tantawy and Abu Elela (2013) and Tantawy *et al*. (2013) found similar results on some clay soils of Egypt. The salinity parameters diminished along the lateral distance and augmented with the depth of the soil profile. Although the effect of drainage period on the soil properties was determined in different areas, the relative change values of the determined parameters may be taken into consideration to reflect the effect of tile drainage on these parameters along the lateral distance, above and the midway of the lateral.

The calculated values of RC (%) show that all values of both EC and TSS are negative Also, these values for the same property increased negatively with expanding the distance from the lateral begin at the same distance of the lateral length, RC values of both EC and TSS above the laterals were more negative compared with those calculated between the laterals. This may be reflect increase efficiency of tile drainage system at the lateral end (near collector) compared with that at any other distances are in agreement with those foundby Abou Hussien and Abou El-Khir (1999), Anter (2000 and 2005) and Tantawy and Abou Elela (2013).

Table (1): Soil salinity in relation to tile drainage system established in (1999) at El - Khadrawyia 1 , Minufiya Governorate (above laterals).

Distance*	Soil depth (cm)	EC dSm^{-1}	Soluble cations(meq / l)				Soluble anions (meq / l)			TSS (%)	SAR
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	$SO_4^{=}$		
Before lateral	0-15	2.11	8.22	3.45	8.63	0.81	8.41	7.65	5.05	0.68	3.57
	15-30	2.51	8.43	7.24	9.02	0.40	6.63	11.85	6.61	0.80	3.22
	30-60	2.41	4.03	8.69	10.40	1.02	6.47	14.80	2.87	0.77	4.12
	>60	6.11	18.20	2.06	40.41	0.40	5.60	51.26	4.21	1.95	12.70
	Mean	3.29	9.72	5.36	17.12	0.66	6.78	21.39	4.69	1.05	5.90
25	0-15	1.62	5.11	2.84	7.45	0.80	5.06	9.63	1.46	0.52	3.74
	15-30	1.82	5.53	3.47	8.80	0.40	5.61	5.88	6.68	0.58	4.15
	30-60	2.11	6.42	4.00	9.68	1.00	5.83	9.41	5.86	0.67	4.24
	>60	3.32	8.69	4.71	19.40	0.40	7.80	18.20	7.20	1.06	7.49
	Mean	2.22	6.44	3.76	11.33	0.65	6.08	10.78	5.30	0.71	4.91
50	0-15	1.41	4.69	2.41	6.43	0.60	4.22	6.33	3.58	0.45	3.41
	15-30	1.50	4.80	2.62	7.17	0.41	4.23	6.72	4.08	0.48	3.72
	30-60	1.78	4.97	3.41	8.82	0.60	4.47	5.18	8.15	0.57	4.31
	>60	2.12	3.85	3.48	13.47	0.40	6.22	8.10	6.83	0.68	7.04
	Mean	1.70	4.58	2.98	8.97	0.50	4.79	6.58	5.66	0.55	4.62
75	0-15	1.30	4.50	2.41	5.66	0.43	4.45	3.91	4.64	0.42	3.05
	15-30	1.42	4.57	2.42	6.70	0.51	4.84	4.49	4.82	0.45	3.58
	30-60	1.70	5.21	3.27	7.85	0.67	5.00	5.13	6.90	0.54	3.81
	>60	1.91	4.41	3.87	10.40	1.40	5.24	7.23	6.61	0.61	5.45
	Mean	1.58	4.67	2.99	7.65	0.50	4.88	5.19	5.74	0.51	3.97
100	0-15	1.11	3.60	2.10	5.02	0.40	3.44	3.68	3.95	0.35	2.97
	15-30	1.32	4.34	2.44	5.76	0.66	4.46	4.25	4.49	0.42	3.13
	30-60	1.52	5.26	2.85	6.36	0.72	4.44	4.41	6.34	0.49	3.16
	>60	1.90	6.28	3.58	8.64	0.50	5.62	4.44	8.95	0.60	3.89
	Mean	1.46	4.87	2.74	6.45	0.57	4.49	4.19	5.93	0.46	3.29
Relative change (RC,%)for the mean values											
25		-32.52	-33.74	-29.85	-33.82	-1.52	-10.32	-49.60	13.01	-32.38	-16.78
50		-48.33	-52.88	-44.40	-47.61	-24.24	-29.35	-69.24	20.68	-47.62	-21.69
75		-51.98	-51.95	-44.22	-55.32	-24.24	-28.02	-75.74	22.39	-51.43	-32.71
100		-55.62	-49.90	-48.88	-62.32	-13.64	-33.78	-80.41	26.44	-56.19	-44.24

* The distance as a percent (%) of lateral length .

The content of soluble cations and anions (meq l^{-1}) in the studied area (Table, 1). Was augmented with the increase of soil depth, where it reduced along the distance of the lateral length. The content of soluble ions above the laterals was lower than that found at the midway of the laterals. Anter (2005), and Tantawy and Abou Elela (2013) obtained similar results.

The data in Table (1) show that, in all studied soil samples, the predominate soluble cations ware Na^{+} followed by Ca^{2+} where the lowest one was K^{+}. On the other hand, soluble K^{+} in the area showed a slight change in the absolute amount or a relative change either along the distance of the lateral or the depth of profile. This may ascribed to the power fixation of the clay soils which relative immobile K^{+} through the soil profile along the distance of the lateral. The predominate soluble anion were Cl^{-} followed by SO_4^{2-} in most soil samples and with HCO_3^{-} in others.

All RC values of the soils content of soluble cations and anions calculated based on the mean values of this content declared decrease in the soluble ions till the laterals end, especially above the laterals (Tables 1,2). Concerning the values of RC for EC, TSS and the content of soluble ions in the studies areas were varied widely for each salinity parameters within the samples. Based on these values of RC may be approved on the tile drainage system efficiency and effect of the soils alinity, where these efficiency was increased with the RC values of these parameters which become more negative. In addition RC values may be used to improve soil salinity parameters response to drainage process. In this respect similar results were obtained by Anter (2000 and 2005), and Tantawy and Abou Elela (2013).

Soil pH.

The presented data in Table (3) declared that, soil pH was increased with the increase of soil depth. That may be ascribed either tothe relative higher content of organic matter and its decomposition that producing anacidic products in the surface layers of soil profiles compared with that found in the deeper one (Tantawy and Abou Elela, 2013). At the same depth of each distance of lateral, soil pH above the lateral was lower than that between them. This may be resulted from the high amount of basic salts or basic ions leached from the soil above the lateral compared with that in midway distance. In addition, pH values above and between lateral at the end of them were lower than those at beginning them. These findings may be due to the leached amounts of soluble basic ions at the end of the lateral. These results are in a harmony with that found by Kumar *et al.* (2005).The values reveal that all RC values of pH were negative and became more negative at the end of laterals either of above or between them. Bharambe *et al.* (2001), Jadhaot*et al*. (2009), and Tantawy and Abou Elela (2013) obtained on similar results.

Soil organic matter (OM).

The soils content (g/ kg) of OM was listed in Table (3). The data reveals that at all distances of laterals length above and between them, the content of OM was decreased with the soil depth. The highest values of OM are found in the surface layer, which resulted from the residuals of cultivated crops and agricultural practices. Also, this content at the same distance and soil depth above the lateral was lower than that found between them. This data reveals that, oxidation and decomposition rate of soil OM above the lateral was higher than that occurred between them. In addition, the soil content of OM was decreased with the distance of laterals length increase above and at a midway of the laterals. These findings resulted from the effect of tile drainage system on soil physical properties specially increasing soil porosity and aeration followed by high decomposition or oxidation rate of soil organic matter, are in agreement with these findings Filipove and Avarvarei (1999), Anter (2000), and Tantawy and Abou Elela (2013) obtained on similar results with heavy clay soil ofNile Delta. Generally the soil is characterized by low content of OM, where more than 98% of these samples was less than 7.0 g kg^{-1} (Table, 3). So, the RC values were negative and this negative increased with expanding the distance from the beginning of lateral at the same distance of the lateral length.

Table (2): Soil salinity in relation to tile drainage system established in (1999) at El-Khadrawyia 1 , Minufiya Governorate (between laterals).

Distance*	Soil depth (cm)	EC dSm^{-1}	Soluble cations(meq / l)				Soluble anions (meq / l)			TSS (%)	SAR
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	$SO_4^=$		
Before lateral	0-15	2.11	8.22	3.45	8.63	0.81	8.41	7.65	5.05	0.68	3.57
	15-30	2.51	8.43	7.24	9.02	0.40	6.63	11.85	6.61	0.80	3.22
	30-60	2.41	4.03	8.69	10.40	1.02	6.47	14.80	2.87	0.77	4.12
	>60	6.11	18.20	2.06	40.41	0.40	5.60	51.26	4.21	1.95	12.70
	Mean	3.29	9.72	5.36	17.12	0.66	6.78	21.39	4.69	1.05	5.90
25	0-15	1.71	5.22	2.85	8.22	0.81	5.11	9.97	2.02	0.55	4.09
	15-30	2.12	6.42	4.41	9.97	0.40	7.00	8.40	5.76	0.68	4.28
	30-60	2.21	6.48	4.52	10.10	1.00	9.22	7.43	5.48	0.71	4.30
	>60	3.50	9.60	4.56	20.44	0.40	7.81	20.41	6.82	1.13	7.68
	Mean	2.39	6.93	4.09	12.18	0.65	7.29	11.55	5.02	0.77	5.09
50	0-15	1.52	4.61	2.65	7.26	0.70	4.04	7.22	3.92	0.49	3.81
	15-30	1.71	4.81	3.67	8.22	0.40	4.20	7.82	5.08	0.55	3.99
	30-60	1.85	4.84	3.83	9.20	0.63	5.20	7.84	5.46	0.59	4.42
	>60	2.21	3.63	2.00	15.65	0.82	5.42	9.60	7.08	0.71	6.60
	Mean	1.82	4.47	3.04	10.08	0.64	4.72	8.12	5.39	0.58	4.72
75	0-15	1.31	4.70	1.75	6.20	0.45	3.72	4.85	4.50	0.42	3.45
	15-30	1.52	5.02	2.12	7.66	0.40	4.45	5.90	4.85	0.48	4.05
	30-60	1.81	5.16	3.25	8.84	0.85	5.09	7.49	5.52	0.58	4.31
	>60	2.11	4.20	3.85	12.41	0.64	7.04	7.65	6.42	0.68	6.19
	Mean	1.69	4.77	2.74	8.78	0.59	5.08	6.47	5.57	0.54	4.50
100	0-15	1.31	4.55	2.40	5.67	0.40	4.21	4.80	4.00	0.42	3.04
	15-30	1.41	4.77	2.64	5.90	0.80	4.26	5.00	4.85	0.45	3.07
	30-60	1.71	4.87	4.00	7.80	0.43	5.55	5.44	6.11	0.55	3.70
	>60	1.95	4.91	4.46	9.51	0.62	5.70	5.80	8.00	0.62	4.39
	Mean	1.60	4.78	3.38	7.22	0.56	4.93	5.26	5.74	0.51	3.55
Relative change (RC,%)for the mean values											
25		-27.36	-28.70	-23.69	-28.86	-1.52	7.52	-46.00	7.04	-26.67	-13.73
50		-44.68	-54.01	-43.28	-41.12	-3.03	-30.38	-62.04	14.93	-44.76	-20.00
75		-48.63	-50.93	-48.88	-48.71	-10.61	-25.07	-69.75	18.76	-48.57	-23.73
100		-51.37	-50.82	-36.94	-57.83	-15.15	-27.29	-75.41	22.39	-51.43	-39.83

* The distance as a percent (%) of lateral length.

Table (3): Soil chemical properties in relation to the tile drainage system established in (1999) in the soils of El-Khadrawyia 1 , Minufiya Governorate.

Distance*	Soil depth cm	Abovelaterals						Betweenlaterals					
		pH**	OM g kg^{-1}	$CaCO_3$ g kg^{-1}	Ex. Na cmolkg^{-1}	CEC cmol kg^{-1}	ESP	pH**	OM g kg^{-1}	$CaCO_3$ g kg^{-1}	Ex. Na cmol kg^{-1}	CEC cmol kg^{-1}	ESP
Before lateral	0-15	8.43	7.40	26.10	3.29	39.56	8.32	8.43	7.40	26.10	3.29	39.56	8.32
	15-30	8.53	6.70	46.40	3.54	36.71	9.63	8.53	6.70	46.40	3.54	36.71	9.63
	30-60	8.58	6.70	28.00	3.95	36.16	10.92	8.58	6.70	28.00	3.95	36.16	10.92
	>60	8.64	6.10	16.50	3.88	33.62	11.55	8.64	6.10	16.50	3.88	33.62	11.55
	Mean	8.55	6.73	29.25	3.67	36.51	10.11	8.55	6.73	29.25	3.67	36.51	10.11
25	0-15	8.15	7.00	29.70	2.96	39.52	7.50	8.15	7.20	28.90	3.16	39.55	8.00
	15-30	8.33	6.40	33.10	3.36	36.77	9.15	8.35	6.40	41.10	3.93	41.76	9.40
	30-60	8.40	6.00	22.70	3.73	36.24	10.30	8.42	6.40	32.70	2.18	26.34	10.67
	>60	8.50	5.70	22.40	4.19	36.47	11.50	8.55	6.00	17.50	3.92	34.06	11.50
	Mean	8.35	6.28	26.98	3.56	37.25	9.61	8.37	6.50	30.10	3.46	35.43	9.89
50	0-15	8.12	6.90	28.20	2.87	42.13	6.82	8.12	6.90	21.40	3.13	43.79	7.15
	15-30	8.30	6.30	32.50	3.58	42.07	8.50	8.33	6.40	41.50	2.89	34.73	8.32
	30-60	8.33	6.00	24.10	3.29	32.73	10.05	8.39	6.40	22.10	3.30	31.14	10.60
	>60	8.38	5.60	11.80	4.21	37.22	11.32	8.40	6.30	19.30	4.36	38.22	11.41
	Mean	8.28	6.20	24.15	3.49	38.54	9.17	8.31	6.50	26.08	3.42	36.97	9.37
75	0-15	8.01	6.80	20.60	2.29	37.55	6.11	8.11	6.80	21.50	2.70	4062	6.65
	15-30	8.27	6.20	12.20	2.91	37.61	7.75	8.27	6.40	30.70	3.04	36.90	8.25
	30-60	8.33	5.90	21.50	3.67	37.85	9.70	8.33	6.40	12.40	3.83	37.73	10.15
	>60	8.36	5.50	21.50	3.83	35.06	10.92	8.37	6.20	15.10	3.60	31.96	11.25
	Mean	8.24	6.10	18.95	3.18	37.01	8.62	8.27	6.45	19.93	3.29	36.80	9.08
100	0-15	7.62	6.40	23.70	2.11	38.44	5.50	8.02	6.50	27.50	2.26	36.27	6.22
	15-30	8.20	6.20	31.90	2.31	32.47	7.10	8.12	6.50	36.40	2.47	31.72	7.80
	30-60	8.31	5.80	21.50	3.49	38.39	9.10	8.27	6.30	22.80	3.57	37.13	9.62
	>60	8.31	5.70	17.50	3.94	36.47	10.80	8.33	6.00	12.90	3.27	29.98	10.91
	Mean	8.43	7.40	26.10	2.96	36.44	8.13	8.19	6.33	24.90	2.89	33.78	8.63
Relative change (RC, %) for the mean values													
25		-2.34	-6.69	-7.76	-3.00	2.03	-4.95	-2.11	-3.42	2.91	-5.72	-2.96	-2.18
50		-3.16	-7.88	-17.44	-4.90	5.56	-9.30	-2.81	-3.42	-10.84	-6.81	1.26	-7.32
75		-3.63	-9.36	-35.21	-13.35	1.37	-14.74	-3.28	-4.16	-31.86	-10.35	0.79	-10.19
100		-5.15	-10.40	-19.15	-19.35	-0.19	-19.58	-4.21	-5.94	-14.87	-21.25	-7.48	-14.64

* The distance as a percent (%) of lateral length .
**pH (1 : 2.5) soil : water suspension.

Exchangeable sodium percentage (ESP):

Exchangeable sodium percentage (ESP) is one of the important parameter used to approve the soil sodicity and alkalinity. Also, this it is a good parameter to estimate the efficiency of drainage system, where it must be highly affected by soil drainage condition. The data in Table (3) manifested ESP of soil samples in the studied areas in relation to the studied variables i.e., soil depth and the distance of the laterals length above and at a midway them. These data appear that ESP was increased with the increase of soil depth which related to greater amounts of sodium leached to deeper layers or with drainage water compared with that of divalent cations (Ca and Mg). At the same soil depth ESP above the laterals was lower than that between them. This may be resulted from the greater amounts of sodium removed from soil above laterals compared with that occurred at a midway of the laterals. The same reason of such reduction explain the decrease of ESP at the laterals end compared with that at any other distance of lateral length either above or between the laterals. In addition all surface layers of the three areas may be classified according to its ESP to non-alkaline soil (<15%), but the deeper layers which have ESP more than 15% classified as alkaline soil (Richards, 1954). Thus and according to data of ESP, and for protection these soils to prevent alkalization forming, gypsum requirements of these soils must be determined and applied at short time.

Finally using ESP to estimate the state of tile drainage systems may be cleared by RC values of ESP presented in Table (3). Values RC of ESP at the selected distance of the lateral compared with before beginning of lateral were negative and the negativity raised at the lateral end especially above theme. Bol'shakov *et al.* (1996) obtained similar results.

Soil Physical Properties.

Bulk density (BD).

Soil bulk density (BD) is one of the best parameters used as indication for the status of soil structure, consequently, the soil water regime through the pore size distribution of the soil. The presented data in Table (4) denote that, soil BD was increased with the increase of soil depth. This may be attributed to high compaction of soil at deeper layers compared with that in the surface layers. On the other hand it may be resulted from high content of organic matter in the surface layers compared with that in the deeper one. In addition, tillage and other farming processes played a major role on this concern. Abou El-Nour (2013) recorded a similar results in fifteen soil profiles represented different areas of Minufiya Governorate. In addition above and between laterals and at the same soil depth in the studied areas soil BD was decreased with elongation distance of the laterals length. These findings were resulted from the lower ESP values at the lateral end compared with those presented at their starting. So in the studied areas the low values of BD were found in the surface layers (0-15cm) above laterals at their ends, but the highest one was found in the deeper layers (>60cm)

The obtained data also declare that, soil BD in the studied areas above the laterals was lower than that found between the laterals . This observation refers to the decrease effect of the drainage on soil BD. These findings may be ascribed to low values of ESP (%) in the different soil layers above the laterals compared with those found at the same depth between the laterals. Previously such these findings were found by Anter (2000 and 2005) with heavy textural saline soil of Kafer El-Sheikh Governorate who found that soil BD was decreased with the decrease in the drainage distances.

The differences in the tile drainage systems efficiency in the studied areas based on the effect of BD may be cleared from the calculated values of RC (Table, 4). These values which calculated based on the mean values of BD at different distances above and between laterals appear that, these values were negativity, wherever it increased either at the end or above laterals, however it was less between them.

Table (4): Soil bulk density (BD), total porosity (TP) and hydraulic conductivity (K) in relation to tile drainage system established in (1999) in the soils of El - Khadrawyia1 , Minufiya Governorate (above and between laterals).

Distance*	Soil depth (cm)	B.D. (g / cm^3)		T.P.(%)		K (cm / h)	
		Above	Between	Above	Between	Above	Between
Before lateral	0-15	1.436	1.436	45.81	45.81	0.47	0.47
	15-30	1.488	1.488	43.85	43.85	0.44	0.44
	30-60	1.496	1.496	43.55	43.55	0.39	0.39
	>60	1.511	1.511	42.98	42.98	0.31	0.31
	Mean	1.483	1.483	44.05	44.05	0.40	0.40
25	0-15	1.287	1.300	51.43	50.94	0.47	0.46
	15-30	1.346	1.357	49.21	48.79	0.46	0.43
	30-60	1.352	1.365	48.98	48.49	0.44	0.43
	>60	1.355	1.366	48.87	48.45	0.36	0.31
	Mean	1.335	1.347	49.62	49.17	0.43	0.41
50	0-15	1.284	1.297	51.55	51.06	0.53	0.53
	15-30	1.338	1.349	49.51	49.09	0.52	0.42
	30-60	1.357	1.368	48.79	48.38	0.52	0.38
	>60	1.359	1.370	48.72	48.30	0.36	0.33
	Mean	1.335	1.346	49.64	49.21	0.48	0.42
75	0-15	1.228	1.239	53.66	53.25	0.61	0.51
	15-30	1.327	1.340	49.92	49.43	0.60	0.50
	30-60	1.338	1.349	49.51	49.09	0.57	0.49
	>60	1.340	1.351	49.43	49.02	0.43	0.47
	Mean	1.308	1.320	50.63	50.20	0.55	0.49
100	0-15	1.186	1.220	55.25	53.96	0.65	0.53
	15-30	1.333	1.344	49.70	49.28	0.62	0.52
	30-60	1.337	1.348	49.55	49.13	0.55	0.50
	>60	1.348	1.358	49.13	48.75	0.42	0.50
	Mean	1.301	1.318	50.91	50.28	0.56	0.51
Relative change (RC, %) for the mean values							
25		-9.980	-9.171	12.645	11.623	7.500	2.500
50		-9.980	-9.238	12.690	11.714	20.000	5.000
75		-11.800	-10.991	14.938	13.961	37.500	22.500
100		-12.272	-11.126	15.573	14.143	40.000	27.500

***** The distance is a percent (%) of lateral length

Total porosity (TP).

The presented data in Table (4) pointed out that, in the studied areas and with all trails of tile drainage system, TP values appeared the opposite trend to that of bulk density. This means that, TP were decreased with soil depth and augmented with extension the distance above and between laterals. In addition, at all soil depths and the distances on the laterals, TP above laterals were higher than that between them. These findings approved the improving effect of tile drainage system on soil physical properties such as soil TP which reflected directly on both soil aeration, water movement and biological activity. Such improving effect was found by Ibrahim (1999), Anter (2000) and Mohamedin and El-Sawaf (2005). In addition, the calculated values of RC (%) of TP reflect the efficiency of tile drainage systems. All RC values were positive and increased at the end of the laterals especially above them compared with those found at a midway of the lateral.

Hydraulic conductivity (K).

Data of soil hydraulic conductivity (cm/h) in the studied areas in relation to tile drainage system as listed in Table (4). These data revealed that, soil K takes the parallel trend of soil TP and reversible trend with soil BD. This means that, tile drainage system establishment were associated by an increase of soil K. The high values of K were recorded for the surface layers above the lateral especially at the end of them where the lowest one was found at the deeper layer before beginning of laterals. These results were confirmed with those found by Anter (2000 and 2005) and Messing and Westrom (2006). All RC values were positive and increased at the end of the laterals especially above them compared with those found at a midway of the lateral.

The Content of Available macronutrients.

Available nitrogen (N).

Data in Table (5) revealed that, the soil content of NH_4-N was minimized with the increase of soil depth. This may be ascribed to the high intensity of negative charges on the soil compound in the surface layers compared with that found on in the deeper layers. On the other hand, the highest content of NO_3-N was found at the soil depth of 15-30 cm or 30-60cm. This may be due to NO_3^- leaching from the surface layers with irrigation water to the deeper one, or may be to effect of drainage system .Similar, results are in harmony with the findings of Abou El-Nour (2013) and Tantawy *et al*. (2013)

Regarding to the relationships between the studied trails of tile draining system and the soil content (mg kg^{-1}) of NH_4-N and NO_3-N as recorded in Table (5), the soil content of available N above the laterals was lower than that found between them. It was obvious with NO_3-N than NH_4-N. These findings may be due to the high leached amounts of available N (NO_3) with irrigation water and high loss of soil organic matter above lateral compared with that found between them. These findings are in agreement with those obtained by Kladiveko *et al.*(1999), Ibrahim (2003) and Singh *et al.* (2007).The same data declared that, either above and between laterals at all depths, the soils content of both NH_4-N and NO_3-N was inhibited with the extension the distance on the laterals in the three studied areas. Thus, the highest content of both NH_4-N and NO_3-N was found before beginning laterals and the lowest one was found at the end of laterals especially above them. That may be attributed to the effective of tile drainage in improving soil properties.

The tile drainage systems efficiency in the studied areas, according to its effect on the soil content of available N may be cleared by calculated values of RC, (%) as presented in Table (5). These values of RC NH_4-N and NO_3-N were negative. Also this negative increased with expanding the distance from the beginning lateral at the same distance of the lateral length.

Available phosphorus P.

Data in Table (5) presented that, the soil content of available P (mg kg^{-1}) in the studied area. The highest content of available P was found at soil depth of 15-30

Table (5) : Soil content of available N, P and K (mg kg^{-1}) in relation to tile drainage system established in (1999) in the soils of El-Khadrawyia 1, Minufiya Governorate (above and between laterals).

Distance*	Soil depth cm	Above laterals				Between laterals			
		NH_4	NO_3	P	K	NH_4	NO_3	P	K
Before Lateral	0-15	36.90	15.63	5.94	231.00	36.90	15.63	5.94	231.00
	15-30	34.97	16.37	5.78	216.45	34.97	16.37	5.78	216.45
	30-60	33.66	17.66	4.86	117.78	33.66	17.66	4.86	117.78
	> 60	33.22	14.76	3.94	113.49	33.22	14.76	3.94	113.49
	Mean	34.69	16.11	5.13	169.68	34.69	16.11	5.13	169.68
25	0-15	34.16	15.70	5.30	231.00	35.01	16.90	6.05	235.21
	15-30	33.70	16.66	4.91	116.55	34.78	17.15	5.56	130.00
	30-60	32.16	16.70	4.87	114.50	33.22	16.09	5.05	122.10
	> 60	31.30	14.00	4.81	113.17	31.15	14.16	3.52	118.00
	Mean	32.83	15.77	4.98	143.81	33.54	16.08	5.05	151.33
50	0-15	33.15	15.08	6.00	231.00	34.91	16.11	5.65	226.00
	15-30	32.15	16.00	5.30	126.20	32.11	16.12	5.31	168.00
	30-60	29.00	15.18	4.00	109.20	31.46	15.24	4.30	100.00
	> 60	27.60	14.32	3.90	93.60	30.16	14.79	4.18	102.54
	Mean	30.47	15.15	4.80	140.00	32.16	15.57	4.86	149.14
75	0-15	32.40	15.25	5.68	222.00	33.00	15.70	5.43	230.81
	15-30	31.00	15.50	5.52	163.80	32.06	15.95	5.12	166.21
	30-60	28.11	15.00	3.82	90.16	27.16	15.55	4.29	95.41
	> 60	26.11	13.75	3.46	75.82	26.78	13.90	4.18	80.75
	Mean	29.40	14.88	4.62	137.95	29.75	15.28	4.76	143.30
100	0-15	31.72	14.95	5.35	220.00	32.13	15.35	5.60	233.02
	15-30	29.50	15.20	4.77	157.51	30.15	15.42	4.38	132.11
	30-60	27.75	14.50	4.37	90.46	27.90	15.15	4.22	90.20
	>60	26.18	13.60	3.21	70.12	26.25	13.71	3.71	80.20
	Mean	28.78	14.56	4.43	127.02	29.11	14.91	4.48	133.88
Relative change (RC , %) for the mean values									
25		-5.36	-2.11	-2.92	-15.25	-3.32	-0.19	-1.56	-10.81
50		-12.16	-5.96	-6.43	-17.49	-7.29	-3.35	-5.26	-12.11
75		-15.25	-7.64	-9.94	-18.70	-14.24	-5.15	-7.21	-15.55
100		-17.04	-9.62	-13.65	-25.14	-16.09	-7.45	-12.67	-21.10

* The distance as a percent (%) of lateral length

cm followed by that at 30-60 cm or 0-15cm and the lowest one was found in the deeper layers. These findings were found above and between laterals at different distances of lateral length. This may be ascribed to the immobility of phosphorus in soil profile and the native low content of P in the deeper layer. Also, in the three studied areas, the soil content of available P above laterals was.

lower than that found at a midway of them. Also, this content at 100% of lateral length was lower than that found before beginning lateral. These findings may be resulted from leached amount of the available P with irrigation water into drains. The other factors such as decreasing soil bulk density and increasing soil porosity were associated by more water movement to the drains containing more amounts of soluble P. In this respect Abou Hussien and Abou El-Khir (1999), Paasonen *et al*. (2003) and Patra *et al*. (2006) obtained similar results.

Approve on tile drainage systems efficiency in the studied area according to its effect on the soil content of available P may be cleared from the calculated values of RC (%) for soil content of available P as recorded in Table (5). These values were negative with all drainage trails, where these values become more negative at lateral ends especially above laterals.

Available potassium (K).

The data of available K (mg kg^{-1}) in the studied areas are presented in Table (5) manifested that, the soil content of available K was decreased with the increase of soil depth. This may be resulted from the high intensity of negative charges on the soil particles in the surface layers compared with that in deeper one. Consequently more fixation for the available K in the upper layer, compared with the lower one. Regarding to the effect of tile drainage system, the obtained data revealed that the content of available K above laterals was lower than that at a midway of the lateral, in El-Khadrawyia 1, Similar observation was found with the distance of lateral length, where the content of available K at the laterals ends was lower than that before it's beginning. This may be induced as a result of greater leaching of the soluble K with irrigation water above laterals especially at the ends of them. These results are in agreement with those obtained by, Abou Hussien and Abou El-Khir(1999), Mathew *et al*. (2001) and Patra *et al.* (2006).

The effect of tile drainage system in the studied areas on the availability of K as calculated in the form of RC (%) tabulated in Table (5). All values of RC were negative. Which refer to that, tile drainage system instillation was associated by decrease of soil content of available K. Such decreases were attributed to the leached amounts of soluble K with irrigation water to deeper layers followed by removal with drainage water. So, these findings may be used as indicator for drainage system efficiency.

The Content of available Micronutrients.

The recorded data in Table (6) show the soil content (mg kg^{-1}) of available Fe, Mn, Zn and Cu in the soils of the studied area, above and between laterals and at different distances of laterals length. The soil content of the determined micronutrients was declined with the increase of soil depth. This may be resulted from the high content of both fine particles and organic matters, in the surface layer, consequently, its relatively higher content of micronutrients, than the deeper one. These results are in coincidence with those obtained by Abou Hussien and Abou El-Khir (1999).

Data in Table (6) denoted that, the soil content of available micronutrients takes the order: Fe > Cu >Mn> Zn. These findings may be attributed to the soil properties of the studied areas, wherever the content of clay, organic matter and CEC appeared the same trend and a good relation to the determined micronutrients, in the studied areas.

The content of available micronutrients above laterals was lower than that found at the middle of them. Also such these decreases were observed with extending the distance of the laterals length. This reduction may be attributed to losses some

Table (6): The soil content(mg kg^{-1}) of available Fe, Mn, Zn and Cu as Affected by tile drainage system established in (1999) in the soils El-Khadrawyia1, Minufiya Governorate (above and between laterals).

Distance*	Soil depth cm	Above laterals				Between laterals			
		Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
Before Lateral	0-15	4.103	2.278	1.000	2.328	4.103	2.278	1.000	2.328
	15-30	3.590	2.060	0.783	2.140	3.590	2.060	0.783	2.140
	30-60	3.263	1.540	0.620	1.713	3.263	1.540	0.620	1.713
	> 60	2.550	1.470	0.325	1.430	2.550	1.470	0.325	1.430
	Mean	3.377	1.837	0.682	1.903	3.377	1.837	0.682	1.903
25	0-15	3.748	2.115	0.975	2.283	3.775	2.188	1.000	2.313
	15-30	3.455	1.928	0.763	2.063	3.403	2.043	0.775	2.105
	30-60	3.105	1.455	0.538	1.658	3.135	1.450	0.610	1.700
	> 60	2.475	1.438	0.330	1.378	2.500	1.405	0.325	1.403
	Mean	3.196	1.734	0.652	1.846	3.203	1.772	0.678	1.880
50	0-15	3.488	2.028	0.738	2.250	3.588	2.198	0.738	2.278
	15-30	3.413	1.780	0.625	2.208	3.485	1.888	0.655	2.053
	30-60	2.548	1.405	0.450	1.655	3.120	1.490	0.595	1.670
	> 60	2.365	1.380	0.295	1.250	2.443	1.415	0.320	1.275
	Mean	2.954	1.648	0.527	1.841	3.159	1.748	0.577	1.819
75	0-15	3.435	1.853	0.578	2.178	3.468	1.998	0.675	2.228
	15-30	2.748	1.780	0.575	1.933	3.410	1.945	0.650	1.988
	30-60	2.340	1.355	0.370	1.588	2.700	1.425	0.405	1.605
	> 60	2.195	1.128	0.250	1.070	2.333	1.313	0.270	1.118
	Mean	2.680	1.529	0.443	1.692	2.978	1.670	0.500	1.735
100	0-15	3.108	1.748	0.525	1.938	3.300	1.913	0.600	2.038
	15-30	2.533	1.480	0.455	1.705	2.975	1.580	0.480	1.810
	30-60	2.288	1.250	0.350	1.565	2.555	1.455	0.400	1.628
	> 60	2.028	1.153	0.250	1.080	2.325	1.130	0.270	1.105
	Mean	2.489	1.408	0.395	1.572	2.789	1.520	0.438	1.645
Relative change (RC , %) for the mean values									
25		-5.360	-5.607	-4.399	-2.995	-5.153	-3.538	-0.587	-1.209
50		-12.526	-10.289	-22.727	-3.258	-6.455	-4.845	-15.396	-4.414
75		-20.640	-16.766	-35.044	-11.088	-11.815	-9.091	-26.686	-8.828

100	-26.296	-23.353	-42.082	-17.394	-17.412	-17.256	-35.777	-13.558

* The distance is a percent (%) of lateral length.

amounts of these nutrients from the soil with drainage water. Also, these decreases may be resulted from the decrease of soil content of organic matter. Similar results are in concordance with Abou Hussien and Abou El-Khir (1999) and Mohamedin (2002).

The drainage period effect on soil fertility or its content of available micronutrients may be cleared from the calculated values of RC (%) for the soil content of available micronutrients as presented in Table (6). In the studied area with all determined micronutrients above and between laterals, all values of RC were negative and its negativity raised at laterals end and above them compared with that found before beginning lateral and at the middle of the same laterals. Also the negative degree of RC values was varied from nutrient to another. Thus RC values may be used to estimate the efficiency of tile drainage system in the studied areas of Minufiya Governorate

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تقييم الخصوبة في أراضي محافظة المنوفية وتأثرها بنظام الصرف المغطى

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الملخص العربي

نفذ هذا العمل لدراسة تأثير نظام الصرف المغطى وإعادة إنشاءه أو تجديده على خصوبة التربة في منطقة الخضراوية الأولى بمحافظة المنوفية حيث جدد نظام الصرف بها في عام ١٩٩٩م , تم أخذ عينات التربة فوق وبين المصارف على خمس مسافات متساوية من طول خط الصرف وهي قبل بداية المصرف و٢٥% و٥٠% و٧٥% و١٠٠% من طول خط الصرف من المبدأ إلى المصب وعلى أعماق: صفر– ١٥، ١٥–٣٠، ٣٠–٦٠، > ٦٠سم وتم تقدير بعض العناصر الميسرة الكبرى والصغرى مثل النيتروجين والفوسفور والبوتاسيوم والحديد والمنجنيز والنحاس والزنك. ويمكن تلخيص النتائج فيما يلى:–

– كان هناك زيادة في قيم EC، TSS، pH، ESP مع عمق التربة ونقصت على طول خط الصرف (من٢٥–١٣٠سم) وكان هذا النقص أكثر وضوحاً فوق المصارف خاصة عند سطح التربة بالمقارنة بالنقص الحادث بين المصارف والقطاعات العميقة من التربة.

– كان هناك زيادة في محتوى النتروجين الميسر بين المصارف بالمقارنة بمحتواه فوق المصارف وكذلك نقص محتوى النتروجين مع زيادة المسافة من طول الخط المصرف فوق وبين المصارف وذلك نتيجة لزيادة الكمية المغسولة من النتروجين الميسر مع ماء الري وكذلك الفقد العالي للمادة العضوية فوق المصرف بالمقارنة بين الخط ونهاية المصرف.

– وجد أن أعلى محتوى للنترات في طبقات التربة على عمق ١٥–٣٠، ٣٠–٦٠سم وكان أقل محتوى وجد في الطبقات العميقة .

– كان أعلى محتوى من الفوسفور والبوتاسيوم الميسر بين المصارف كذلك نقص المحتوى فوق وبين المصارف مع زيادة المسافة على طول خط الصرف – المحتوى من المغذيات الصغرى الميسرة سلك نفس اتجاه النتروجين والفوسفور وكان ترتيب العناصر كالتالي: الحديد > النحاس > المنجنيز > الزنك.

The Content of Available macronutrients.

Available nitrogen (N).

Data in Table (5) revealed that, the soil content of NH_4-N was minimized with the increase of soil depth. This may be ascribed to the high intensity of negative charges on the soil compound in the surface layers compared with that found on in the deeper layers. On the other hand, the highest content of NO_3-N was found at the soil depth of 15-30 cm or 30-60cm. This may be due to NO_3^- leaching from the surface layers with irrigation water to the deeper one, or may be to effect of drainage system .Similar, results are in harmony with the findings of Abou El-Nour (2013) and Tantawy *et al*. (2013)

Regarding to the relationships between the studied trails of tile draining system and the soil content (mg kg^{-1}) of NH_4-N and NO_3-N as recorded in Table (5), the soil content of available N above the laterals was lower than that found between them. It was obvious with NO_3-N than NH_4-N. These findings may be due to the high leached amounts of available N (NO_3) with irrigation water and high loss of soil organic matter above lateral compared with that found between them. These findings are in agreement with those obtained by Kladiveko *et al.*(1999), Ibrahim (2003) and Singh *et al.* (2007).The same data declared that, either above and between laterals at all depths, the soils content of both NH_4-N and NO_3-N was inhibited with the extension the distance on the laterals in the three studied areas. Thus, the highest content of both NH_4-N and NO_3-N was found before beginning laterals and the lowest one was found at the end of laterals especially above them. That may be attributed to the effective of tile drainage in improving soil properties.

The tile drainage systems efficiency in the studied areas, according to its effect on the soil content of available N may be cleared by calculated values of RC, (%) as presented in Table (5). These values of RC NH_4-N and NO_3-N were negative. Also this negative increased with expanding the distance from the beginning lateral at the same distance of the lateral length.

Available phosphorus P.

Data in table (5) presented that, the soil content of available P (mg kg^{-1}) in the studied area. The highest content of available P was found at soil depth of 15-30 cm followed by that at 30-60 cm or 0-15cm and the lowest one was found in the deeper layers. These findings were found above and between laterals at different distances of lateral length. This may be ascribed to the immobility of phosphorus in soil profile and the native low content of P in the deeper layer. Also, in the three studied areas, the soil content of available P above laterals was.

lower than that found at a midway of them. Also, this content at 100% of lateral length was lower than that found before beginning lateral. These findings may be resulted from leached amount of the available P with irrigation water into drains. The other factors such as decreasing soil bulk density and increasing soil porosity were associated by more water movement to the drains containing more amounts of soluble P. In this respect Abou Hussien and Abou El-Khir (1999), Paasonen *et al*. (2003) and Patra *et al*. (2006) obtained similar results.

Approve on tile drainage systems efficiency in the studied area according to its effect on the soil content of available P may be cleared from the calculated values of RC (%) for soil content of available P as recorded in Table (5). These values were negative with all drainage trails, where these values become more negative at lateral ends especially above laterals.

Available potassium (K).

The data of available K (mg kg^{-1}) in the studied areas are presented in Table (5) manifested that, the soil content of available K was decreased with the increase of soil depth. This may be resulted from the high intensity of negative charges on the soil particles in the surface layers compared with that in deeper one. Consequently more fixation for the available K in the upper layer, compared with the lower one. Regarding to the effect of tile drainage system, the obtained data revealed that the content of available K above laterals was lower than that at a midway of the lateral, in El-Khadrawyia 1, Similar observation was found with the distance of lateral length, where the content of available K at the laterals ends was lower than that before it's beginning. This may be induced as a result of greater leaching of the soluble K with irrigation water above laterals especially at the ends of them. These results are in agreement with those obtained by, Abou Hussien and Abou El-Khir(1999), Mathew *et al*. (2001) and Patra *et al.*(2006).

The effect of tile drainage system in the studied areas on the availability of K as calculated in the form of RC (%) tabulated in Table (5).All values of RC were negative. Which refer to that, tile drainage system instillation was associated by decrease of soil content of available K. Such decreases were attributed to the leached amounts of soluble K with irrigation water to deeper layers followed by removal with drainage water. So, these findings may be used as indicator for drainage system efficiency.