MERIT RESEARCH JOURNALS
www.meritresearchjournals.org

Merit Research Journal of Agricultural Science and Soil Sciences (ISSN: 2350-2274) Vol. 4(2) pp. 023-032, February, 2016
Available online http://meritresearchjournals.org/asss/index.htm

Original Research Article

Controlled drainage effects on nitrate leaching, salinity buildup and sugar beet production (Egypt)

El-Ghannam M.K.[1*], M. E. Abo Waly[2], S. A. Gaheen[2], F. F. Karajeh[3] and A. A. Gendy[1]

[1]Soils, Water and Environment Res. Inst., Agric. Res. Center. Egypt.

[2]Dept. Soil Sci., Fac. Agric., Kafr EL-Sheikh Univ, Egypt

[3]Food and agriculture organization, Cairo office, FAO

***Corresponding Author's E-mail: elghnam_mkh@yahoo.com**

Abstract

Subsurface tile drainage has been effective in draining croplands. Detailed controlled studies were undertaken in order to understand the salt dynamics under rice and associated crops and their impact on soil and drainage water quality. This includes the influence of different crop rotations, farm practices, and subsurface drainage status on salt build-up. An on-farm study was conducted to determine the influence of controlled drainage on salinity build up though soil profile, nitrogen losses, drain discharge and crop productivity. A farm was divided into five 2.5 ha plots and planted sugar beet. One of the plots had a free tile drainage system at 1.20 m depth, and others plots were installed with a controlled drainage system at 0.4, 0.6, 0.8 and 1 m. The objectives of study were to determine the effect of controlled drainage on salinity build up and losses of nitrogen. Results indicated that the soil salinity values for the shallower water table depth at 40cm were nearly two times the salinity values of the deepest layers compared to the values in the top layers. It can be seen that, the controlled drainage resulted in significantly less drainage than allowing free drainage. The controlled drains only flowed between 24-48 hours for with first treatment 40 cm depth of water table, while the discharge from the free drainage treatment occurred for over 192 hours. Flow weighted mean NO^-_3 concentration of tile drainage water was reduced 44.5% from 37.83 kg fed^{-1} for the 120 cm free drainage treatment to 20.99 kg fed^{-1} for the controlled drainage at 40 cm depth of water table treatment in 2013 season under sugar beet crop. In the second season, the average annual NO^-_3 loss was reduced 51.94 % from 33.79 kg fed^{-1} for the 120cm treatment to 16.15 kg fed^{-1} for the CD at 40 cm treatment. The area of influence indicated a controlled drainage yield advantage of 24.4 and 30 % for 2013 and 2014 season, respectively. The greater yield advantage from this method compared to the free drainage, this suggests that this practice could generate more profit than free drainage fields.

Keywords: Controlled drainage, Drain discharge, Nile Delta, NO^-_3 concentration crop productivity, Water table

INTRODUCTION

Salinity management in the crop root zone is essential for the sustainability of irrigated agriculture and is a major consideration when proposing controlled drainage practices. Research has demonstrated that water and salt will move upwards from shallow ground water and may result in salinized soil in a short time. Patel et al.

(2000) found that the salinity of the sub irrigation water affected soil solution salinity in the upper soil profile when the water table was maintained at 0.4 m depth. The sub irrigation water also affected the lower half of the soil profile when the water table was maintained at 0.8 m depth; however, it did not affect any salt buildup in the upper half. Also, in this study the addition of N, P, and K fertilizers did not contribute to the salt buildup in the soil. Christen and Skehan (2001), The salt concentration and composition of deeper groundwater are largely a reflection of the geological and origin of the different aquifer formation , whereas for a shallow (phreatic) ground water , salt concentration and composition reflect the balance between the different source of recharge and discharge and the interaction between ground water and soil salinity. The management of the water balance is likely to be more effective in managing productivity and the off-site impacts of irrigation than managing a farm or regional salt balance. Hornbuckle (2003) showed that controlled drainage significantly reduced drainage volumes and salt loads compared to unmanaged systems. However, there were marked increases in soil salinity which will need to be carefully monitored and managed. Ayers et al. (2005) reported that capillary up flow from shallow groundwater is a significant contributor of soil salinization in irrigated areas and is highly dependent on water table position and salinity. The top layer of the shallow groundwater is a dynamic zone, reflecting the interaction between the ground water, soil water and the infiltrating irrigation water. Processes occurring in this zone, such as mixing, solute transport, interactions with the soil matrix, and fluctuations in the water table may result in salinity variations over short time periods. Doering et. al., (1982) determined that uncontrolled drainage systems were over-draining land and recommended a shallow water table concept for drainage design as a means to reduce drainage flow, and proposed a shallow drainage installation concept to increase crop water use from shallow ground water in semi-arid areas with good quality groundwater. Drainage water management, in the context of subsurface agricultural drainage, consists of managing outflow or designing it with a goal of reducing drainage volume. Drainage water management can be accomplished by shallower drain placement or through managing the outlet of the subsurface drainage systems during certain portions of the year (i.e., controlled or management drainage) (Wortmann et. al., 2006). Zhonghua et. al., (2006) showed that for rice planation in China (the major water use crop), controlled drainage could reduce subsurface discharge through field ditches up to 94%. However, for wheat and corn, the benefit of controlled drainage was negligible, since the major drainage discharge was directly through the main ditch system and the Yellow River Channel. Specifically, the drainage system would be managed to reduce drainage outflow during times of the year when drainage is not necessary. For shallower drain placement, the drains would be placed closer together to maintain a consistent drainage intensity or drainage design rate (Strock et al., 2011).

Ng et al. (2001) reported that the flow weighted mean nitrate concentration of the drainage water was reduced by 70% from 19.2 mg per liter Nitrate (N) (?) for FD treatment to 11.3 mg per liter N for the controlled drainage treatment. Hence, the net effect of slightly increased drainage volumes and dramatically lower nitrate concentrations with the CDS treatment resulted in a cumulative nitrate loss of 36.8 kg N kg N per hectare soil compared to 57.9 kg N per hectare for the FD treatment. The FD treatment increased total nitrate loss by 57% compared to the CDS treatment. Nangia (2005) showed that increasing tile spacing from 27 to 100 m (240% increase at a fixed depth of 0.9 m) decreased flow by 8% and decreased nitrate-N by 44% (21.3 to 11.9 kg/ha). Decreasing tile depth from 1.5 to 0.9 m (a 40% decrease at a fixed spacing of 27 m) decreased flow by 25% and decreased nitrate-N losses by 53% (44.9 to 21.3 kg/ha). Increased tile drain spacing or decreased tile drain depth could be a remedy for excess nitrate-N loads in the Gulf of Mexico. In studies involving drainage water management, both flow volumes and NO_3 concentrations are usually monitored in order to estimate changes in NO_3 loading as a result of drainage water management implementation (Evans and Skaggs, 2004; Breve et al., 1997; Gilliam et al., 1979; Tan et al., 1998). In most cases, measured NO_3 load reductions in a field using drainage water management were largely dependent on reductions in the flow volume. There have also been observations of reductions in NO_3 concentration, often attributed to increased denitrification within the managed soil profile (Lalonde et al., 1996; Mejia et al., 1998; Madramootoo et al., 2001; Gilliam et al. 1979). The volume of water that penetrated through the soil was a primary factor responsible for N loss (Tan *et al.*, 1993; Drury *et al.*, 1996). A controlled drainage/ sub irrigation system reduced annual tile drainage volume by 24% over a 3-years period (Drury *et al.*, 1996), Flow weighted mean nitrate concentration was reduced by 25% with controlled drainage/sub irrigation compared with the free drainage treatments. The average annual nitrate loss was reduced by 43%, from 25.8 kg N per ha for the free drainage treatment to 14.6 kg N per ha , for the controlled drainage/sub irrigation treatments. Gilliam *et al.* (1978) showed that controlled drainage reduced nitrate transport by nearly 50 per cent compared to conventional drainage practices. Lalonde *et al.* (1996) showed that controlled drainage had a significant effect on drainage flow quality and quantity. Conservation tillage in combination with controlled drainage/sub irrigation reduced annual nitrate loss by 49% (Drury *et al.* 1996). Controlled drainage and sub irrigation systems have also improved crop yields in some years compared to free drainage treatment in the

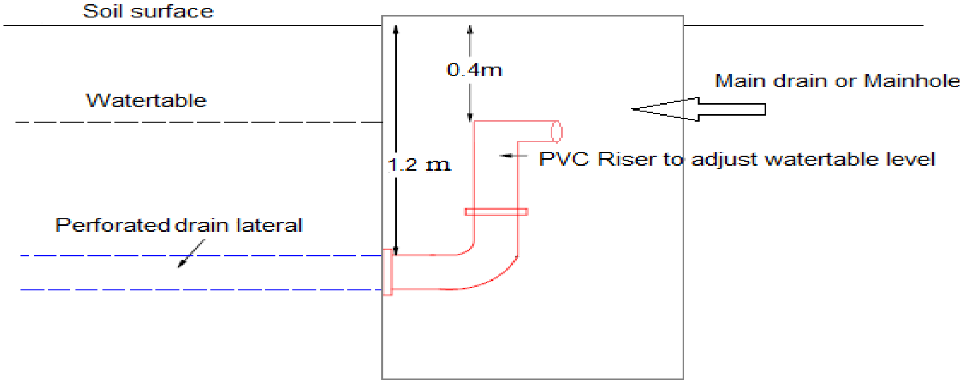

Figure 1. Illustrate of the control valve.

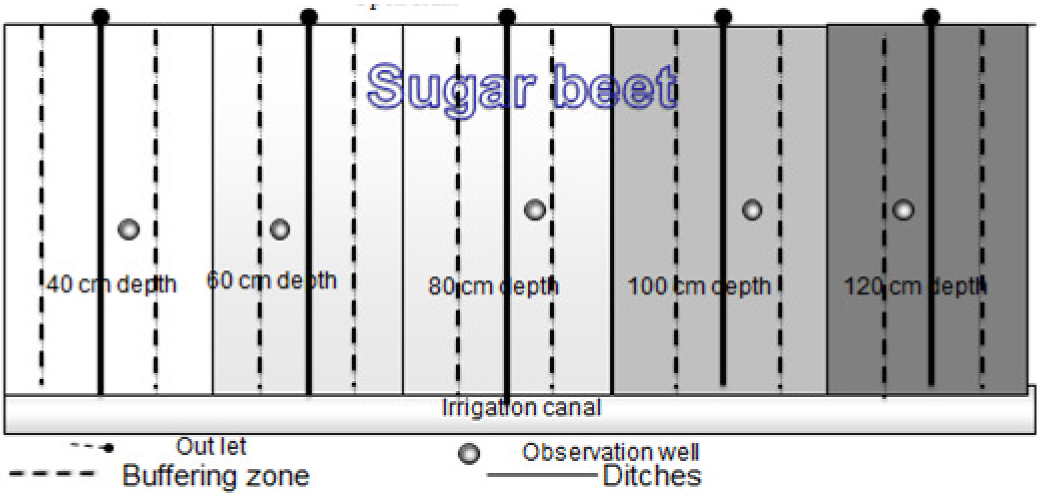

Figure 2. The layout of the controlled drainage experiment

clay loam and sandy loam soils (Tan et al., 1993; Tan et al., 1996). Controlled drainage and subsurface irrigation have been demonstrated by field scale and greenhouse studies as a viable technology to reduce nitrate loss and improve crop yields (Drury et al., 1997). Fang et al (2012) suggested that N loss can be reduced by about 40% in both FD and CD by decreasing N rate from 245 to 140 kg N ha^{-1} with little effect on corn yield. A further reduction in N loss of 39% (9.3 kg N ha^{-1}) was simulated by implementing CD at the reduced N rate, and the reduced N loss to tile flow was mainly associated with increased N loss to seepage (lateral flow) and crop N uptake.

MATERIALS AND METHODS

A Field experiment was conducted in two successive winter seasons during the 2013/2014 and 2014/2015, at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate, Egypt (31˚ 07¯ N and 30˚ 57¯ E, 6m msl). The study area is characterized by semi-arid Mediterranean climatic conditions.

Some physical and chemical characteristics of the soil under investigation are given in Table (1). The area served by tile drainage system, which was adapted to carry out the current study (Figure 1). It is divided into five treatments each one drained by three laterals connected to riser through a manhole and the drain spacing is 20 m. five drainage treatments were adopted in this study i.e.:

a. Controlled drainage: (1) water table depth is 100 cm below soil surface.
b. Controlled drainage: (2) water table depth is 80 cm below soil surface.
c. Controlled drainage: (3) water table depth is 60 cm below soil surface.
d. Controlled drainage :(4) water table depth is 40 cm below soil surface.
e. Conventional drainage: (5) drain depth is 120 cm below soil surface.

Construction of controlled drainage system:

Table 1. Some physical and chemical properties for the soil at the experimental site.

Parameter	Value
1- Physical properties :	
- Particle size distribution (%)	
Clay	50.03
Silt	33.27
Sand	16.70
Texture class	Clay
Bulk density	1.21
- Field capacity (%)	39
- Welting point (%)	21
- Available water (%)	18
2- Chemical analysis :	
ECe (dS/m)	1.29
pH	8.05
- Soluble cations (meq/l)	
Na+	7.30
K+	0.16
Ca++	4.20
Mg++	5.13
- Soluble anions (meq/l)	
CO3-	0.00
HCO3--	3.40
SO4--	7.79
Cl-	5.60

‘Controlled drainage’ a device to the fix the level of ground water to a delimit depths in the different treatments (0, 1, 2, 3, 4).

Approach needs to be that the irrigation and drainage systems become an integrated water management system. This implies into reactivity between the operation of the irrigation system and the management of the drainage system.

In this instance, the drainage system will be managed to control the flow and water table depth in the course of time in response to the irrigation management and deep percolation. Controlled drainage devices were installed at different treatments. The system consists of 3" vertical pipe of 120cm height. The riser was connected at the bottom to the lateral inside the manhole. The watertable is controlled at the required level using opened stop-log as follow:

Installation of observation wells

15 wells were installed to observe the fluctuation of watertable and collecting ground water samples for chemical analysis. The observation wells were installed using polyethylene tubes with a 5cm diameter and 2m length. Tubes were perforated at the lower end and covered with permeable materials and screen to allow easy movement of groundwater to the tubes and to avoid the clogging by clay and fine particles. The tubes were put in the prepared auger holes to a depth of 170cm and the residual 30cm length of the tube was left above soil surface. The fluctuation of watertable in observation wells was regularly registered using a sounder device. (Cavelares, 1974).

Measurements of irrigation and drainage water discharge

Drain discharge rates were measured by using a bucket and stopwatch and were observed two times every day when drain flow occurred, by measuring the amount of water running from tile line during a short interval and converting water flow to m3ha-1. The average daily discharge rates were used in this study. Several water samples from tile effluent (as drainage water) were collected at different times of the day and composite daily samples were taken for analysis of salinity (Early, 1975).

Agricultural practices: Sugar beet crop

Sugar beet crop (variety Nada) was sown on the 5th of November, 2013 and the harvesting date was on 29 May, 2014. In second season sugar beet crop (variety Nada) was sown on the 1th of November, 2014 and the harvesting date was on 25 May, 2015. Nitrogen, phosphorus, and potassium fertilizers were added according to the recommended doses of North Delta area.

Soil samples

Soil samples were collected from soil surface down to the watertable depth each 30cm intervals. Soil samples were collected for chemical and physical properties analysis. Soil samples were analyzed according to recommended methods as shown in table (1).

Sugar beet yield and yield components

Plants from four inner ridges or two furrows of each plot were harvested, collected, and cleaned. Roots and shoots were separated and weighed by kg then it was treated to estimate: Root yield (kg/fed.) and Shoots yield (kg/fed.)

Water samples

✓ Water samples were filtrated using filter paper No. 1. and subjected to chemical analysis as follows: EC, and soluble cations and anions were determined as described by (Rowell, 1995).
✓ Total Soluble Nitrogen in irrigation, drainage and soil water, Forms of soluble nitrogen were determined in the studied water samples as NO3- as described by (Cottenie et al. 1982).

Statistical analysis

All the collected data for the yield and yield components of sugar beet crop was subjected to the statistics analysis according to Snedecor and Cochran (1967) and the mean value were compared by L.S.D test at 5% probability level. The experiment was complete block design in three replicates.

RESULTS AND DISCUSSION

Soil salinity as affected by controlled drainage system under sugar beet during the two successive season's 2013 and2014

Data of soil salinity values as affected by controlled subsurface drainage under sugar beet crop during the two growing seasons 2013 and 2014 are shown in table (2) and figures (1 and 2). The mean values of soil salinity during 2013 season before conducting the experiment were 1.22, 0.92, 1.24, 1.62 and 1.64 dS m-1 and the values of soil salinity 4.08, 4.32, 3.49, 1.65 and 1.61 dS m-1 were after harvesting of sugar beet for 40, 60, 80, 100 and 120 cm depth of water table treatments, respectively, it is obvious from the data the shallow water table depth lead to salt accumulation in all soil depths. While, the deepest ones resulted in leaching salts from the surface layers of soil profile. The same trend was shown in 2014 season. Results indicated that the soil salinity values for the shallower water table depth at 40cm were nearly two times the salinity values of the deepest layers compared to the values in the top layers.

It's worth to mention that, soil salinity increased in all layers at 40, 60 and 80 cm depth of water table, higher increases were observed in the upper soil layers, particularly in the 0-30 cm and 30- 60 cm layers. While the increases salinity in soil do not reduce the measured wheat yields, it's apparent that sustainability issues will need to be carefully considered when implementing controlled drainage. Similar results were obtained by Hornbukle (2003).

These data are in agreement with that obtained from kandil et al 1995; they stated that the shallower of ground water, the easier upward movement by capillarity rise where it can be evaporated under the prevailing hot and dry conditions, leaving its load of soluble salts at the surface. The accumulating salts can be redistributed by irrigation water and water table management through the whole profile.

Fluctuation of water table depth during the growing season of sugar beet as affected by controlled drainage.

The depth of water table reached the lowest value immediately before irrigation, while the maximum water table reached at 2 days after irrigation, seasonal averages of water table depth were 35 and 125 cm for maximum and minimum water table depths at controlled drainage treatments, respectively in the 1st season. While the corresponding values in the 2nd season were 31.5 and 115 cm).

Regarding the effect of controlled drainage on water table level, the deepest values of water table 125 and 115 cm were observed at the free drainage in 2013 and 2014 seasons respectively. Whereas, the shallowest values of water table 35 and 31.5cm were recorded at 40 cm treatment in 2013 and 2014 seasons respectively. It can be obtained, the absolute values of both minimum and maximum depth of water table increased directly with increasing percentage of soil moisture and as much as raising the outlet or closing the valves at predetermined depths. This result was in the same direction with those reported by (Ayars et al., 2006).

Results showed that, water table levels decreased after irrigation to the lowest value by the end of the first

Table 2. The soil salinity values during seasons 2013 and 2014 for sugar beet crop as affected with controlled drainage.

Treatments	Soil depths (cm)	Ec dSm^{-1} 2013			Ec dSm^{-1} 2014		
		Initial	Mid	End	Initial	Mid	End
40 cm	0-30	1.95	3.07	5.01	2.59	3.15	5.45
	30-60	0.91	1.16	4.38	1.21	1.50	2.54
	60-90	1.16	2.76	3.38	1.54	2.24	3.24
	90-120	0.84	1.12	3.55	1.12	1.54	3.35
	mean	1.22	2.03	4.08	1.62	2.34	3.40
60 cm	0-30	0.95	1.49	4.43	1.95	2.10	3.50
	30-60	1.16	3.30	4.15	1.54	2.24	2.80
	60-90	0.82	2.61	4.25	1.09	1.10	2.29
	90-120	0.73	2.64	4.45	0.97	1.41	2.04
	mean	0.92	2.51	4.32	1.22	1.76	2.56
80 cm	0-30	0.97	1.01	3.10	1.29	1.87	2.71
	30-60	1.04	1.76	3.50	1.38	2.01	2.91
	60-90	1.40	1.21	3.61	1.86	1.90	3.91
	90-120	1.56	1.95	3.75	2.07	3.01	3.20
	mean	1.24	1.48	3.49	1.65	2.40	3.47
100 cm	0-30	1.40	1.33	1.45	1.86	1.77	2.15
	30-60	1.28	1.22	1.70	1.70	1.62	2.00
	60-90	1.43	1.36	1.50	1.90	1.81	1.80
	90-120	2.38	2.26	1.95	3.17	3.01	2.25
	mean	1.62	1.54	1.65	2.16	2.05	2.05
120 cm	0-30	1.52	0.88	1.00	2.02	2.40	2.00
	30-60	1.26	0.99	1.63	1.68	1.85	2.68
	60-90	1.58	1.10	1.81	2.10	1.79	2.59
	90-120	2.19	1.65	2.00	2.91	2.48	2.15
	mean	1.64	1.16	1.61	2.18	2.13	2.36

day, then gradually increased with elapsing the time after irrigation. Irrigation events which produce higher recharge emphasize the major differences between controlled and uncontrolled drainage system and their effect on the water table regime. Its worth to mention that, the water table level at 40, 60 and 80 cm treatments rose more rapidly and remained higher for longer time than the free drainage treatments. The time that the average water table depth was above specified depths between irrigation intervals from 3-7 days depend on a depth. It can be seen that, the controlled drainage at 40, 60 and 80 cm treatments had higher proportion of time that the water table depth was above 80 cm allowing potential beneficial use by the controlled drainage. The control valves installed on the drainage lateral were effective in maintaining a higher water table in the controlled drainage treatments, which had a significant effect on the drainage volumes and salt loads. In general, the fluctuation of water table regime for sugar beet could be summarized under the current study as follows.

Irrigation regime and controlled drainage had a main effect on the regime of water table. The free drainage at 120 cm depth of water table, the deepest is water table and vice versa.

Drain discharge flow during the growing season of sugar beet as affected by controlled drainage

Water table management systems may be designed to control drainage volumes, peak flow rates or chemical losses from agricultural fields or catchments. Hydrologic impacts will depend on the degree and method of drainage improvement. Design of the drainage system, particularly with regard to drain spacing and intensity of surface drainage, can have a large influence upon the proportion of outflow that occurs via surface runoff which is fast and that which moves more slowly via subsurface flow.

Data in table (3) showed that, the mean values of drains discharge flow as affected by controlled drainage treatments under sugar beet crop during the two successive seasons 2013 and 2014. The highest rates of drain discharge were found with planting irrigation as compared to other irrigations.

Concerning to the treatments of 40, 60 and 80 cm the drains discharge were started during irrigation and increase until to reach the high value after few hours from irrigation then decreased with time for all irrigation cycles. Antar (2005 and 2007) and Ramadan et al. (2009), they found that in clay soil, the majority of discharge water is

Table 3. The mean values of drain discharge flow during the growing season of sugar beet as affected by controlled drainage during 2013 and 2014 seasons.

Year	Time after irr Hour	Drain discharge flow mm day $^{-1}$ in 2013 and 2014				
		Controlled drainage treatments				
		T 40	T 60	T 80	T 100	T 120
2013	24 H	1.3	2	3.2	3.95	4.25
	48 H	2.4	1.75	2.55	3.1	3.20
	72 H		1.25	1.5	2.1	2.75
	96 H			0.55	0.95	1.75
	120 H				0.65	1.25
	144 H				0.55	0.85
	168 H					0.80
	192 H					0.50
2014	24 H	3.15	3.61	3.9	4.5	5.45
	48 H	1.25	2.10	2.5	3.25	3.75
	72 H		0.85	2	2.45	3
	96 H				1.25	2.5
	120 H				0.95	2.1
	144 H				0.65	1.25
	168 H				0.55	1.0
	192 H					0.95

from water movement through soil cracks and macro pores.

There was a marked variation; the cumulative drain discharge (m3fed.-1) was higher under 120 than 40 cm. The values of total cumulative drain discharge were 396, 630, 753.5, 955 and 1261 m3fed-1 in 2013 season, while in 2014 season these values were found to be 414, 595, 729, 935 and 1320 m3fed-1for test water table levels of 40, 60, 80, 100 and 120cm, respectively.

It can be seen that, the controlled drainage resulted in significantly less drainage than allowing free drainage. The controlled drains only flowed between 24-48 hours for with first treatment 40 cm depth of water table, while the discharge from the free drainage treatment occurred for over 192 hours.

The different flow volumes had a large effect on the salt loads, the free drainage removed significantly more salts than the controlled drainage treatments. After each season the control valves removed from the controlled drainage laterals to allow the drains to flow freely and some salts were leached. This provided the opportunity to compare the performance of those laterals with and without pipe.

Losses of nitrate fertilizers as affected by controlled drainage

Drainage water management practices can target agronomic goals, environmental (water quality) goals, or both. The drainage outlet can be set at or close to the soil surface between growing seasons to recharge the water table, thereby temporarily retaining contaminated water in the soil profile where it will be subjected to attenuating and nitrate transforming processes.

Data in table (4) showed the nitrate losses as affected by controlled drainage during the two successive seasons 2013 and 2014 under sugar beet crop. Flow weighted mean NO−3 concentration of tile drainage water was reduced 44.5% from 37.83 kg fed-1 for the 120 cm free drainage treatment to 20.99 kg fed-1 for the controlled drainage at 40 cm depth of water table treatment in 2013 season under sugar beet crop. In the second season, the average annual NO−3 loss was reduced 51.94 % from 33.79 kg fed−1 for the 120cm treatment to 16.15 kg fed−1 for the CD at 40 cm treatment. It can be concluded that the volume of water that flowed through the soil was a primary factor responsible for N loss (Tan et al., 1993 and Drury et al., 1996).

Data illustrated in table (4), inducted that the amount of nitrate had been saved to sugar beet crop in 2013 season under different treatments were 16.84, 12, 8.45 and 4.88 kg N fed-1, for the 40, 60, 80, and 100 cm water table depths, respectively as compared to 120 cm depth. Concerning water table management under wheat crop, the 40 cm depth of controlled drainage saved about 51.94% of nitrate fertilizer, meanwhile, the 100 cm depth realized less percentage of nitrate saving of 18.38% as compared to 120 cm depth in 2014 season.

In most cases, measured NO3 load reductions in a field using drainage water management were largely dependent on reductions in the flow volume. (Lalonde et al. 1996; Mejia et al., 1998; Madramootoo et al. 2001;

Table 4. The seasonal of nitrate losses as affected by controlled drainage under sugar beet crop in the two successive seasons 2013 and 2014.

Treatments	Seasonal Nitrate loss as affected with controlled drainage 2013				
	T 40	**T 60**	**T 80**	**T 100**	**T 120**
Drained water m3/fed	396.00	630.00	753.40	955.00	1261.00
NO_3^- Loss ppm/season	53.00	41.00	39.00	34.50	30.00
NO_3^-loss kg/fed/season	20.99	25.83	29.38	32.95	37.83
NO_3^- saving kg/fed	16.84	12.00	8.45	4.88	0.00
NO_3^- saving %	44.52	31.72	22.32	12.89	-
Seasonal Nitrate loss as affected with controlled drainage 2014					
Drained water m3/fed	414.00	595.00	729.00	935.00	1320.00
NO_3^- Loss ppm/season	39.00	35.00	33.50	29.50	25.60
NO_3^-loss kg/fed/season	16.15	20.83	24.42	27.58	33.79
NO_3^- saving kg/fed	17.65	12.97	9.37	6.21	-
NO_3^- saving %	51.94	38.50	27.70	18.35	-

Table 5. The average values of root yields and its components as affected by controlled drainage during the two successive seasons.

T	Root Yield ton/fed	Shoot Yield ton/fed	Root Length (cm)	Root Diameter (cm)
40	23.364 a	8.837 a	21.92 e	12.51 a
60	21.337 b	8.302 b	22.82 d	11.33 b
80	19.306 c	7.775 c	24.17 c	10.82 c
100	18.770 d	6.776 d	25.18 b	10.09 d
120	17.650 e	6.224 e	26.43 a	9.62 e
F-test	*	*	*	*
40	20.821 a	9.381 a	18.84 e	12.25 a
60	19.755 b	8.146 b	20.21 d	11.20 b
80	18.230 c	7.477 c	21.40 c	10.63 c
100	16.473 d	6.718 d	23.22 b	9.38 d
120	14.639 e	5.923 e	24.45 a	8.76 e
F-test	*	*	*	*

Gilliam et al. 1979).

Regarding to data in table (4) showed that the losses of nitrate concentration decreased from 53 ppm to 39 ppm at 40cm treatment in 2013 and 2014 season, and increasing percentage of nitrate saving at the same depth from 44.52 to 51.94 % may be due to increasing the performance and validity of controlled drainage under studied conditions.

Effect of controlled drainage on yield and yield components and its quality of sugar beet crop during the two successive seasons

Root yields and its components

The two key components of sugar beet yield are the weight of sugar beet roots and the % sugar content of them. The combination of a high root yield and high sugar content will give the highest yield of sugar per area. The effects of different water table depths on sugar beet crop during the two growing season 2013 and 2014 are shown in table (5) the highest average values of root yield (23.364 and 21.337 ton/fed) were obtained at 40 and 60cm depth of water table in 2013 season and (20.821, 19.755 ton/fed) in 2014 season, while the lowest values 17.650 and 14.639 ton/fed in2013 and 2014 seasons at 120 cm depth of water table.

Regarding to top yields, data showed that, the maximum yield (8.837 and 9.381ton/fed) were observed at 40 cm depth of water table in 2013 and 2014 respectively. Whereas, the minimum top yields (6.224 and 5.923 ton/fed) were recorded at free drainage 120 cm depth of water table in 2013 and 2014 seasons respectively. It was clear from the obtained results that increasing the ground water table depth had pronounced effect in decreasing both root and top yields in both growing seasons. Similar results were reported by Antar et al. (2012).This reduction however, was more pronounced at 1.2 m depth probably due to less availability of water for crop use and low soil fertility.

There was marked variation; the area of influence indicated a controlled drainage yield advantage of 24.4 and 30 % for 2013 and 2014 season, respectively. The greater yield advantage from this method compared to the free drainage, this suggests that this practice could generate more profit than free drainage fields.

Root length and root diameter (cm)

Data in table (5), indicated that the controlled subsurface drainage had significant effect on length and diameter of roots in two seasons. It is clear that the highest value of root length 26.43 and 24.45 cm were obtained in 2013 and 2014 seasons respectively, at 120 cm depth of water table and the lowest values of root length 21.92 and 18.84 cm in 2013 and 2014 at 0.4cm depth of water table treatment.

There was a marked variation, the maximum of root diameter12.51 and 12.25 cm in 2013 and 2014 seasons were recorded at 40 cm depth of water table, while the minimum root diameter 9.62 and 8.76 cm were recorded at free drainage 120cm depth of water table treatment in 2013 and 2014 seasons. Results showed that the deepest water table enhanced deep rooting and shallowest water table increased diameter roots. Such results are in harmony with that Ibrahim et al. (2002) and El-zayat. (2000).

CONCLUSION

1. A soil has water table at shallow depths lead to salt accumulation in all soil depths. While, the deepest ones resulted in leaching salts from the surface layers of soil profile.
2. The amount of nitrate had been saved to sugar beet crop by 51% of nitrate fertilizer.
3. Controlled drainage increased yield by 20.7 % at shallow water table depth compared the free drainage in 2013 and 2014 seasons and can provide more profit to the framers.
4. Controlled drainage significantly reduced drainage volumes and salt loads compared to unmanaged systems. However, there were marked increases in soil salinity which will need to be carefully monitored and managed.

ACKNOWLEDGMENTS

My appreciation to my supervisors for their guidance and support. Thanks are also extended to ARC, ICARDA scientists.

REFFERENCES

Antar SA (2005). Movement of some nitrogen forms, atrazine and malathion in clay soil as affected by drain spacing's. Ph.D. Thesis, Agric Fac. Tanta Univ. Egypt.

Antar SA (2007). Nitrate transport in clay soils and its losses into field drains tiles from UREA applied for sugar beet. J. Agric . Sci. Mansoura Univ., 32 (6). 4987-4998.

Antar SA, HA Khafagi IE, Nasr El-Din, IA El-Saiad (2012). Effect of tile drainage and laser land leveling on some soil properties and production of sugar beet and wheat crops. J, of Soil Sciences and Agricultural Engineering. Vol. 3 (1): 1-15.

Ayars JE, EW Christen, JW Hornbuckle (2006). Controlled drainage for improved water management in arid regions irrigated agriculture. Agric. Water Manag. 86: 128-139.

Ayars JE, EW Christen, RW Soppe, WS Meyer (2005). The resource potential of in-situ shallow ground water use in irrigated agriculture: a review Irrig Sci (2005) 24: 147–160

Breve MA, RW Skaggs, JW Gilliam, JE Parsons, AT Mohammad, GM Chescheir, RO Evans (1997). Field testing of DRAINMOD-N. Transactions of the American Society of Agricultural Engineers 40(4):1077–1085.

Cavelaars J (1974). Subsurface field drainage system. Drainage principles and application. Pub. 16: IV, 27. Ins. Land Reclamation and improvement, Wageningen, The, Netherlands.

Christen EW, D Skehan (2001). Design and management of subsurface horizontal drainage to reduce salt loads. ASCE J. Irrig. Drain. Eng. 127, 148–155

Christen EW, JE Ayars (2001). Subsurface drainage system design and management in irrigated agriculture: best management practices for reducing drainage volume and salt load. Technical Report 38-01. CSIRO Land and Water, Griffith, NSW, p. 2680.

Cottenie A, M Verloo, G. Velghe, L. Kiekens (1982). Biological and analytical aspects of soil pollution. Labo of Analytical and Agro. State Univ. Chent. Belgium.

Doering EJ, LC Benz, GA Reichman (1982). Shallow-watertable concept for drainage design in semiarid and subhumid regions. In: American Society of Agricultural Engineers (Eds.), Proceedings of the Fourth National Drainage Symposium on Advances in Drainage, vol. ASAE Publication 12–82. American Society of Agricultural Engineers, St.Joseph, MI, pp. 34–41.

Drury CF, CS Tan, JD Gaynor, TO Oloya, IJ van Wesenbeeck, DJ McKenney (1997). Water table control effects on nitrate leaching, denitrification and corn production. Soil Sci.Soc. Am. J. (In press)

Drury CF, CS Tan, JD Gaynor, TO Oloya, TW Welacky (1996). Influence of controlled drainage-subirrigation on surface and tile drainage nitrate loss. J. Environ. Qual. 25:317-324.

Early AC (1975). Irrigation scheduling for wheat in the Punjab. CENTO Scientific programme on the optimum use of water in Agriculture Report No. 17, Lyallpure Pakistan , March , 3-5,pp. 115-127 .

El-Zayat MM (2000). Effect of irrigation regimes and fertilization on sugar beet. Ph.D Thesis. Fac.Agric. Tanta, Univ. Kafr elsheikh.

Evans RO, RW Skaggs (1996). Operating controlled drainage and subirrigation systems. North Carolina Cooperative Extension Service: AG 356

Evans RO, RW Skaggs (2004). Development of controlled drainage as a BMP in North Carolina. *In* Drainage VIII Proceedings of the Eighth International Symposium, American Society of Agricultural Engineers, 001–015. St. Joseph, MI: American Society of Agricultural and Biological Engineers.

Fang QX, RW Malone, L. Ma, DB Jaynes, KR Thorp, TR Green, LR Ahuja (2012). Modeling the effects of controlled drainage, N rate and weather on nitrate loss to subsurface drainage. Agricultural Water Management 103(January):150-161.

Gilliam JW, RW Skaggs, SB Weed (1978). An evaluation of the potential for using drainage control to reduce nitrate loss from agricultural fields to surface waters. Report No, 128. Water Resource Research Institute of the University of North Carolina. Raleigh, N.C.

Gilliam JW, RW Skaggs, SB Weed (1979). Drainage control to diminish nitrate loss from agricultural fields. Journal of Environmental Quality 8(1):137–142.

Hornbuckle JW (2003). The impact of subsurface drainage design and management on salinity and irrigation water use in a semi-arid environment. Ph.D. Thesis. University of New England, Armidale.

Hornbuckle JW, EW Christen, RD Faulkner, JE Ayars (2004). Controlled drainage management to minimise salt loads. In: Dogramaci, S., Waterhouse, A. (Eds.), Proceedings of the First National Salinity Engineering Conference on Engineering Salinity Solutions, November 9–12, 2004, Burswood International Resort, Perth, Western Australia.

Ibrahim MM, MR Khalifa, MA Koriem, FI Zein, EH Omer (2002). Yield and quality of sugar beet crop as affected by mid to late season drought and potassium fertilizer at north nile delta. Egypt. J.Soil. Sci.42, No1. 87-102.

Lalonde V, CA Madramootoo, RS Trenholm, RS Broughton (1996). Effects of controlled drainage on nitrate concentrations in subsurface drain discharge. Agricultural Water Management 29:187-199.

Madramootoo CA, TG Helwig, GT Dodds (2001). Managing water tables to improve drainage water quality in Quebec, Canada. Transactions of the American Society of Agricultural Engineers 44(6):1511–1519.

Mejia MN, CA Madramootoo (1998). Improved water quality through water table management in eastern Canada. Journal of Irrigation and Drainage Engineering 124(2):116–122.

Nangia V (2005). Field- and watershed-scale evaluation of water quality trends due to changes in landscape and management practices. University of Minnesota. Mexico.

Ng HY, CS Tan, CF Drury, JD Gaynor (2001). Controlled drainage and subirrigation influences tile nitrate loss and corn yields in a sandy loam soil in Southwestern Ontario. Agriculture, Ecosystems and Environment 90(1):81–88.

Patel RM, SO Prasher, RB Bonnell (2000). Effects of watertable depth, irrigation water salinity, and fertilizer application on root zone salt buildup *Agricultural and Biosystems Engineering, Macdonald Campus of McGill University* CANADIAN AGRICULTURAL ENGINEERING Vol. 42, No. 3

Ramadan SA, AS Antar, AA El-Leithi, IE Nasr El-Din (2009). Impact of different nitrogen forms and K added on N and K losses into drainage water under cotton cultivation in clay soil of north delta. J. Agric. Res. Kafer El-Sheikh Univ., 35 (2), 776 – 790.

Rowell DL (1995). Soil Sciences Methods and Applications. Library of Congress Cataglogin-in publication data. New York, Ny. 1158-USA.

Snedecor GA, WC Cochran (1967). Statistical method 6ed Oxford and IBH. Publishing Co. Calcutta India .

Strock JS, GR Sands, MJ Helmers (2011). Subsurface drainage design and management to meet agronomic and environmental goals. *In* Soil Management: Building a Stable Base for Agriculture, ed. J.L. Hatfield and T.J. Sauer. Madison, WI: American Society of Agronomy, Soil Science Society of America.

Tan CS, CF Drury, JD Gaynor, IJ Van Wesenbeeck, M Soultani (1996). Effect of water-table management and nitrogen supply on yield, plant growth and water use of corn in undisturbed soil columns. Can. J. Plant Sci. 76:229-235.

Tan CS, CF Drury, JD Gaynor, TW Welacky (1993). Integrated soil, crop and water management system to abate herbicide and nitrate contamination of the Great Lakes. Water Sci. Technol. 28:497-507.

Tan CS, CF Drury, M Soultani, IJ van Wesenbeeck, HYF Ng, JD Gaynor, TW Welacky (1998). Effect of controlled drainage and tillage on soil structure and tile drainage nitrate loss at the field scale. Water Science and Technology 38(4-5):103–110.

Wortmann CS, M Al-Kaisi, MJ Helmers, J Sawyer, D Devlin, C Barden, P Scharf, R Ferguson, W Kranz, C Shapiro, R Spalding, D Tarkalson, J Holz, D Francis, J Schepers (2006). Agricultural nitrogen management and water quality protection in the Midwest. RP189 Heartland Regional Water Coordination Initiative. Ames, IA: Iowa State University Extension.

Zhonghua JW, S Luo, NW Fang, L Wang (2006). Current drainage practices and feasibility of controlled drainage in the YinNan Irrigation District. China Agric. Water Manag. 84: 20-26.