19

Egypt. J. Soil Sci. 43, No. 2, pp. 285-301 (2003)

Water Table Fluctuation and Salinity in Relation to Land and Water Management Systems

S. M. Ibrahim, M. A. Koriem and S.A. Gaheen

Soil Sci. Dept., Fac. Agric., Kafr El-Sheikh, Tanta Univ., Egypt.

THIS STUDY was undertaken to investigate the fluctuation and salinity of ground water in the soils of Kafr El-Sheikh Governorate, north Nile Delta, as influenced by cropping, irrigation and drainage management systems. For this purpose, shallow observation wells were established in 227 sites distributed in the different regions of the Governorate. Water table levels were recorded daily during the period Nov.1999 - Sept. 2000. Ground water samples were taken monthly from the observation wells during the period Nov. 1999 April 2000 to determine salt content (BC-values) of the ground water. The obtained data were used to evaluate the present irrigation and drainage systems under north Nile Delta conditions.

The obtained results showed that the lands of studied regions have a fluctuated shallow water table. The yearly mean water table level, for all crops with the exception of rice, ranged between 32 cm and 150 cm with overall mean of 77 cm. This means that contribution of ground water by upward flux could form an additional component to the irrigation water supply. The depth of water table depends on the water management associated with each crop. Mean depths of water table during winter season were 72.7, 72.8, 82. 4, 99.0, 109.8 and 124.7 cm under berseem, sugar beet, wheat, faba bean, winter vegetable crops and citrus trees, respectively. The corresponding values during summer season were 32.8, 58.9, 70.1, 72.8, 79.1 and 111.3 cm under rice, sugar cane, maize summer vegetable crops, cotton and citrus trees, respectively. Deeper water table levels were recorded under pipe drainage system (overall mean 85.1 cm) than that under open drainage (mean value = 73.3 cm). The differences between the different pipe drain spacings were not obvious due to the large variability in growing crops, irrigation management and local conditions. Mean salt content (BC values) of the ground water ranged between 1.0 and 14.8 dS/m, with high values in the eastern and northern regions irrigated with mixed water. Higher EC values were also observed in the regions with shallower water table depths.

Concerning the performance assessment of the water management systems, the results showed that low relative ground water depths (RGWD) were obtained in the studied sites due to excessive irrigation and cultivation of large areas with rice. Excessive drainage (rate of water table drawdwon, RWTD, values more than 1.0) is anticipated in the case of pipe drain spacing equal to or less than 35 m, while poor drainage was evaluated in the case of open drainage and pipe drainage with drain spacing of 50 m and 60 m. The bad water management (low RGWD values) in many regions could be attributed to bad irrigation management (excessive irrigation) more than to poor drainage. It is recommended to regulate the irrigation so that no excessive irrigation water is applied to the soils, and also to use a modified drainage system layout in the regions with rice fields in a rotation with other crops.

Keywords: Ground water, Irrigation and drainage conditions, Performance assessment, Land and cropping management, Nile Delta.

The depth of water table is an indicator of the prevailing soil water conditions, water supply, aeration, hydrological and hydraulic properties of the soil (Feddes, 1988 and Ibrahim and Khalifa,1995). Ramirez and Finnerty (1996) found that water table fluctuations had a pronounced effect on root zone soil moisture, irrigation water use requirement and agricultural benefits. Shallow ground water is a problem on an estimated one-half of the existing irrigation areas in the world (Rhoades and Loveday, 1990). Traditionally, subsurface drainage has been used to control the depth of the water table and to permit leaching of salts from irrigated soils. The problem of how to manage irrigation and drainage systems for best utilization of the shallow ground water resource is an important question in arid irrigated areas (Ayars and Hutmacher, 1994).

The water table fluctuation and salinity would be influenced by many factors such as amount and quality of irrigation water, intervals between irrigations, crop type, and drainage conditions (Ibrahim & Khalifa, 1995; Kanwar *et al.*

1998; Oztekin *et al.*, 1998 and Ibrahim, 2000) . Evaluation of the fluctuation and salinity of water table is necessary under intensified irrigation and cropping systems, and scarce water supply in north Delta region, for effective soil, water and cropping management. Knowledge of the effects of land and water management systems on depth and salinity of water table is important. This provides data for better management and use of the avaible water resources. It is now realized that many of the irrigation and drainage projects are not functioning well and the anticipated benefits of these projects could not be attained because of environmental degradation in the form of water logging and soil salinity (Gupta *et al.*, 1998).

During the 1980s concern about poor performance of existing irrigation and drainage systems were highlighted globally and a number of Performance Assessment Indicators (PAIs) were proposed (Bos, 1996). In spite of this, there has been a general lack of performance assessment exercises in Egypt. Therefore, one purpose of the present study is to identify PAIs which have direct relevance to irrigation and drainage systems in north Nile Delta. The aims of the present study are: (1) to give more information on the fluctuations of water table in the soils at Kaf El-Sheikh Governorate, north Nile Delta, during a whole year under different land management, irrigation and drainage conditions. (2) to evaluate the influence of land and water management systems on the depth and salinity of water table, (3) to identify Performance Assessment Indicators (PAIs) of water management system in north Nile Delta.

Material and Methods

Daily water table levels were recorded in the soils of 227 sites distributed in Kafr El-Sheikh Governorate, north Nile Delta during the period first November 1999 - end September 2000. The measurements were made in observation wells (plastic pipes 38 mm diameter, 2 m deep with few holes through the pipe near the bottom end). Ground water samples were collected from the observation wells once a month during the period Nov.1999 - April 2000 and salt contents (BC values) were determined as the methods described by Richards (1954). Averages of PC-values were used in the present study.

The studied sites were chosen to represent wide variation in land and cropping management systems: wheat, sugar beet, clover, beans, maize, cotton, rice, sugar cane, vegetable crops and citrus trees, under different drainage conditions: open drainage, tile drainage with different drain spacings (60,50, 40,35, 30, 25, and 15 m) and under flood irrigation system with different irrigation water quantity according to the location, crop type, and available irrigation water amounts as well as different irrigation water qualities (Nile water and mixed irrigation water) according to the location.

Two indicators are identified on the basis of average depth to water table to evaluate irrigation and drainage systems (Bos, 1996). These indicators are given as follows:

Relative Ground Water Depth (RGWD)

$$RGWD = \frac{\text{Average depth to water table in the season}}{\text{Intended depth to water table in the season}}$$

For a well operated drainage system, the value of RGWD should be more than or equal to 1.0. It is proposed in north Nile Delta conditions that the intended depth to water table could be 100cm.

On the basis of non-steady state drainage theory, an indicator for performance assessment is "Rate of Water Table Drawdwon (RWTD)" which is given as follows:

$$RWTD = \frac{\text{Fall of water table in a given period}}{\text{Intended depth of fall in the given duration}}$$

Intended depth of fall as per design criterion commonly followed in Egypt could be 50 cm in 3 days (Abdel Dayem *et al.*, 1998).

Results and Discussion

1- The general pattern of water table fluctuations

The daily measurements of water table showed that the water table levels reached the soil surface upon irrigation and dropped until they reached a low level before the next irrigation. Such general trend was observed in all studied sites but the drop rate of water table and the lowest levels varied according to location, growing crop, irrigation and drainage conditions. Water table level fluctuated between 0 and 191 cm during the winter growing season, and between 0 and 185 cm during the summer growing season.

The mean water table levels for the 227 studied sites are presented in Fig. 1 and 2 for winter and summer seasons, respectively. The mean water table level for the studied sites ranged between 33 cm and 150 cm during winter growing season. The corresponding values during summer growing season ranged between 8 cm and 59 cm for the rice cultivated soils after other crops, and between 32 cm and 150 cm under other summer crops. The overall mean value of water table level was 77.7 cm during winter season. The corresponding levels in summer season were 65.7 cm and 76.0 cm for all summer crops and for other summer crops without rice, respectively. In general, the lands of the studied locations were characterized by a high water table, refering to bad irrigation and drainage management.

Comparison between the regime of water table during winter and summer growing seasons and visual inspection of Fig. 1 and 2 show that water table levels are higher during summer season than those during winter season. This could be attributed to higher volume of applied irrigation water in summer, as well as the presence of large areas cultivated with rice, which requires pounded conditions and causes water seepage to the neighbouring fields. Water table depth varied between the different regions. High depths were recorded in the northern region near the sea and also in the areas with excessive use of irrigation water. In the following sections, the data are analyzed to determine the relationship between water table depth and land management, as well as irrigation and drainage conditions.

2- Land management - water table relations

In spite of the general pattern of water table fluctuation, there are large variations in water table depth between different winter and summer crops. The 227 studied sites were divided into five main regions. Mean values of water table depth during winter growing season are presented in Table 1. The winter crops were: clover (130 sites), wheat (30 sites), sugar beet (50 sites), faba bean (9 sites), winter vegetables crops (5 sites), and citrus trees (3 sites). High water table levels were recorded under clover and sugar beet than those under other winter crops, due to shorter irrigation intervals and therefore higher amounts of irrigation water. The depth of water table under the winter crops can be arranged in the following descending order: citrus trees > vegetable crops > faba been > wheat > sugar beet and clover.

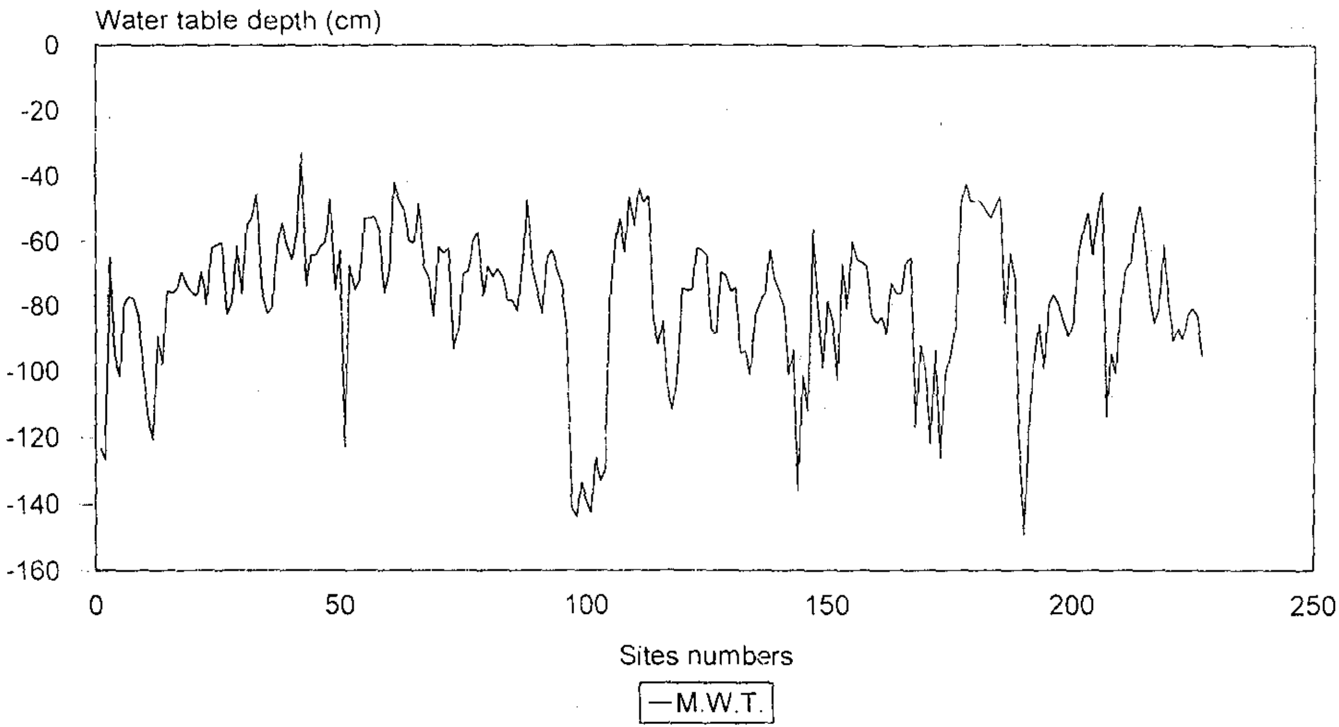

Fig. 1. Mean water table depth for the studied sites during winter season (1 Nov. 1999-30 April 2000).

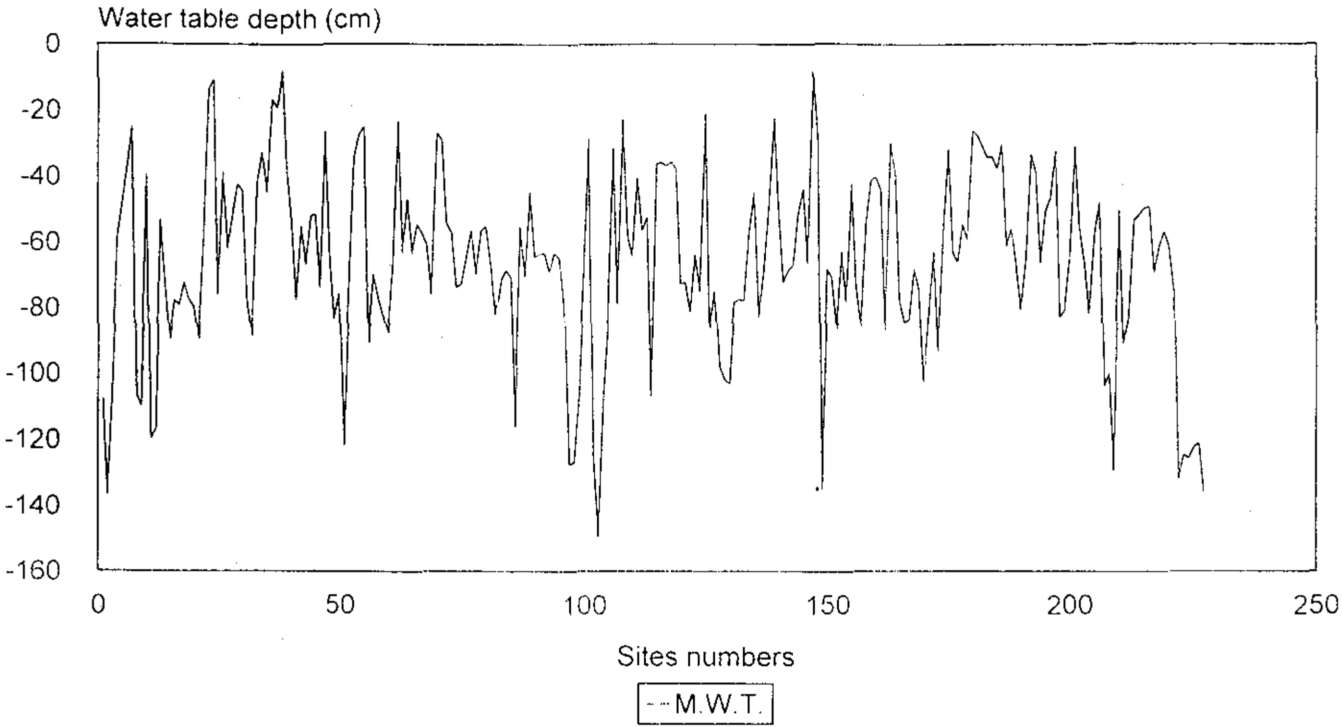

Fig. 2. Mean water table depth for the studied sites during summer season (1 May 2000-30 Sept. 2000).

Mean values of water table depth during summer growing season are presented in Table 2. The summer crops were: maize (24 sites), cotton (90 sites), summer vegetables crops (44 sites), sugar cane (2 sites), citrus trees (3 sites), and rice (64 sites). The water table levels were usually closest to the soil surface under rice crop. High mean water table levels were recorded under sugar cane, maize, and summer vegetables crops, those were 58.9cm, 70.1 cm, and 72.8 cm respectively. The mean values of water table depth under cotton and citrus trees were 79.1 cm and 111.3 cm, respectively.

TABLE 1. Mean water table depth (in cm) in the studied regions during winter growing season (1 Nov.1999 -30April 2000).

Region	Berseem	Wheat	Sugar beet	Faba bean	Vegetable crops	Citrus trees	General Mean
East	75.5	85.0	65.8	-	123.0	-	76.3
North	72.2	70.6	70.0	91.5	77.5	124.7	75.9
Middle	77.7	74.7	80.5	-	-	-	78.7
West	71.0	108.6	60.7	101.1	124.5	-	81.7
South	69.6	97.5	84.7	-	99.4	-	77.3
Average*	72.7	82.4	72.8	99.0	109.8	124.7	77.7

*In all tables in the paper, the sites numbers in every region were taken into consideration when the average values were calculated.

TABLE 2. Mean water table depth (in cm) in the studied regions during summer growing season (1 May 2000 - 30 Sept. 2000).

Region	Maize	Cotton	Vegetable crops	Sugar cane	Citrus trees	Rice*	General mean	
							With rice	Without rice
East	95.5	91.9	63.0	-	-	34.1	62.6	78.3
North	64.3	72.4	107.6	-	111.3	27.9	65.9	72.9
Middle	-	75.5	76.3	-	-	36.1	69.3	75.0
West	76.4	74.8	70.8	-	-	32.5	59.3	71.5
South	49.2	85.7	57.0	58.9	-	33.5	75.2	80.4
Average	70.1	79.1	72.8	58.9	111.3	32.8	65.7	76.0

*The soils were bare or cultivated with other crops until middle July and then with rice.

3-Soil drainage -water table relations

The studied sites, represent wide variations in soil drainage conditions (Table 3) as follows: open drainage (9 sites); and pipe drainage with drain spacing of: 60 m (10 sites), 50 m (12 sites), 40 m (28 sites), 35 m (4 sites), 30 m (152 sites), 25 m (9 sites), and 15 m (2 sites). Generally, deeper water table levels were recorded under pipe drainage system (overall mean = 85.1 cm) than that under open drainage (mean value = 73.3 cm). The high water table depths under pipe drain spacing of 40 m are attributed to the existence of large areas cultivated with clover and sugar beet in winter season, and with rice, vegetable crops and sugar cane in summer season.

The general lack of differentiation between water table depths under the different drain spacings is caused by the large variability in growing crops, irrigation practices and local conditions as well as the presence of large areas of rice fields in summer season. Under the current conventional drainage tile layout, water seepage from the rice fields rises the water table in the neighbouring fields. Similar results were obtained by Abdel Dayem *et al.* (1989).

TABLE 3. Yearly mean water table depth (in cm) in the studied regions under different drainage conditions.

Region	Open drainage	Pipe drainage with drain spacings of:						
		60 m	50 m	40 m	35 m	30 m	25 m	15 m
East	-	-	-	-	-	77.5	62.2	-
North	68.0	-	-	-	-	72.8	97.9	109.2
Middle	84.0	76.1	83.5	74.4	89.2	71.8	-	-
West	-	81.9	-	72.9	85.3	77.2	-	-
South	-	106.7	68.3	66.6	-	85.6	-	-
Average	73.3	96.2	75.9	71.3	86.3	77.0	80.1	109.2

4. Salinity of ground water

The mean of salt contents (BC values) of the ground water of the 227 studied sites are presented in Fig. 3 and in Tables 4 and 5. Differences between the different sites are attributed to the differences in cropping, irrigation and drainage management. As shown in Fig. 3, the mean of BC-values ranged between 1.02-14.8 dS/m with overall mean of 3.5 dS/m. The highest BC-values were recorded in northern region (sites number 46-119). Generally, high water table

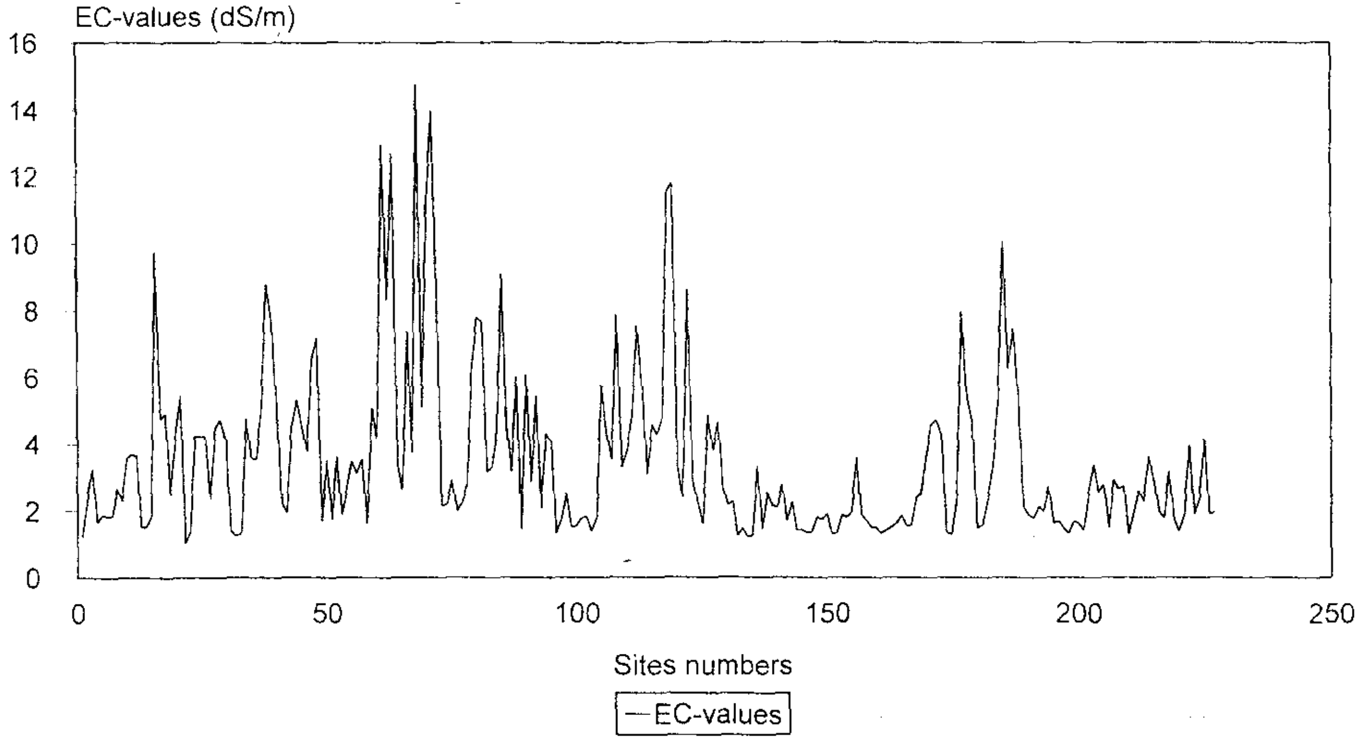

Fig. 3. Mean electrical conductivity (EC-values, in dS / m) of the groundwater in the studied sites during winter season (1 Nov. 1999-30 April 2000).

depth is associated with high EC values of such water. Similar results were obtained by Ibrahim (2000) in North Nile Delta and by Gad (1999) under the Nile Valley conditions. High salts content were recorded in the ground water in the eastern and northern regions due to the recorded high watertable depths (Table 1) on one hand, and due to the use of mixed irrigation water, the neighbourhood to the Burullus lake and the Mediterranean Sea on the other hand. The three sites cultivated with citrus trees have an adequate new installed tile drainage system with drain spacing of 15 m, therefore such soil had the deepest water table with the lowest EC-values (1.86 dS/m). The salt content in the ground water under winter crops can be arranged in the following descending order: sugar beet> wheat> faba bean> clover > vegetable crops> citrus trees.

TABLE 4. Electrical conductivity (EC values, in dS/m) of ground water in the studied regions during winter growing season (1 Nov. 1999-30April 2000).

Region	Berseem	Wheat	Sugar beet	Faba bean	Vegetable crops	Citrus trees	Range	General mean
East	3.59	2.89	4.09	-	1.20	-	1.0-8.8	3.51
North	4.45	5.64	5.29	6.83	6.27	1.86	1.3-14.8	4.82
Middle	2.07	8.64	2.94	-	-	-	1.2-8.6	2.71
West	2.23	2.42	6.29	2.84	1.38	-	1.3-10.1	2.81
South	2.04	2.43	2.55	-	2.73	-	1.3-4.2	2.27
Average	3.13	4.17	4.21	3.72	2.59	1.86	1.0-14.8	3.51

TABLE 5. Electrical conductivity (EC-Values in d S/m) of ground water in the studied regions under different drainage conditions.

Region	Open drainage	Pipe drainage with drain spacings of:							General mean
		60 m	50 m	40 m	35 m	30 m	25 m	15 m	
East	-	-	-	-	-	3.42	4.78	-	3.51
North	4.15	-	-	-	-	4.82	6.67	1.53	4.82
Middle	4.45	2.28	1.30	2.98	2.16	2.25	-	-	2.71
West	-	1.52	-	1.77	1.39	3.20	-	-	2.81
South	-	2.72	2.05	2.23	-	2.26	-	-	2.27
Average	4.25	2.32	1.86	2.40	1.58	3.81	6.04	1.53	3.51

Data in Table 5 show also that the tile drained lands have lower salt content in the ground water than that the open drained lands, with the exception of the sites with 25 m drain spacing because they located only in the eastern and northern regions where higher water table depths were recorded and mixed irrigation water was applied. Generally, the salinity of the ground water in many of the studied regions is not high. This means that the ground water in Nile Delta soils can be evaluated as a potential source of irrigation water.

5. Performance assessment of irrigation and drainage systems

Performance of drainage systems in a semi-arid region is related to its hydraulic functioning to control of the water table and in lowering the soil salinity in the root zone (Hiler,1977 and Gupta *et al.*, 1998). The water table is the most desirable drainage requirement criterion. The relative ground water depth (RGWD) in winter season observed to be less than 1.0 in 1 85 sites and equal to or more than 1.0 in 42 sites. The corresponding values in summer season were 197 and 30 sites, respectively. The data in Table 6 present the mean values of the two determined performance assessment indicators during winter season under different drainage conditions. The mean values of RGWD were found to be less than 1.0 under all drainage conditions with the exception of pipe drainage with 35 m drain spacing. This would mean poor drainage. But as Gupta *et al.* (1998) reported a well drainage performance can be expected with RGWD between 0.8 and 1.2. The low RGWD values in the studied sites could be attributed to bad irrigation system management (excess irrigation) more than to poor drainage.

TABLE 6. RCWD and RWTD values under different drainage systems.

	Open drainage	Pipe drainage with drain spacing of:				
		60 m	50 m	40 m	35 m	25 m
RGWD	0.75	0.86	0.81	0.71	1.06	0.87
RWTD	0.59	0.62	0.78	0.95	1.25	1.65

The values of the rate of water table drawdwon (RWTD) in Table 6 indicate excessive drainage (RWTD values more than 1.0) in the case of 35 m and 25 m drain spacings, while poor drainage is anticipated in the case of open drainage and pipe drainage with 50 m and 60 m drain spacings. The pipe drainage with 40 m drain spacing is well operated and gives RWTD values equal to 0.95.

Generally, high water table depth and low RGWD were observed in the studied sites, due to over-irrigation and cultivation of large areas with rice. Also, lateral seepage occurs as a result of the non-uniform irrigation conditions where dry fields exist in the neighbourhood of irrigated ones. It is necessary to use a modified drainage system layout as reported by El-Guindy *et al.* (1987) that should be prepared so that the rice fields should have a drainage system which could be regulated independently. This modified system layout was described by Abdel Dayem *et al.* (1989). The irrigation system should be regulated so that no excess irrigation water is added to the soil.

Acknowledgement: The authors would like to thank University of Tanta for the financial support of the present study.

References

Abdel Dayem, S., Ritzema, H.P., EL-Atfy, H.E. and Amer, M.H. (1989) Pilot areas and drainage technology. In: *"Land Drainage in Egypt,"* M.H. Amer, and N.A. de Ridder (Eds.), DRI, Cairo .

Abdel Dayem, S., Rashed, A.A., Hamza, M. and Broughton, R.S. (1998) Performance of some drainage systems in the Nile Delta. *Proc. 7th Intern. Drainage Symposium*, 8-10 March, Orlando, Florida, pp. 338-346.

Ayars, J.E. and Hutmacher, R.B. (1994) Crop coefficients for irrigating cotton in the presence of ground water. *Irrig. Sci.* **15**,45.

Bos, M.C. (1996) Performance indicators for irrigation and drainage. In: *Sustainability of Irrigated Agriculture.* The Evaluation of Performance of Subsurface Drainage Systems. 16th Congress of ICID, Cairo, pp. 17-34.

El-Guindy, S. , Rissecuw, I. and Nijland, H. (1987) Research on water management of rice fields in the Nile Delta, Fgypt. *Publication No.41, ILRI.* Wageningen, The Netherlands.

Feddes, R.A. (1988) Fffects of drainage on crops and farm management. *Agr. Water Manage.* **14**, 3.

Gad, A. (1999) The effect of irrigation practices on the ground water table of some alluvial soils; EL-Menia Governorate, Egypt. *Egypt. J. Soil Sci.* **39**(3), 325.

Gupta, S.K., Sharma, D.P. and Rao, K.V.G.K. (1998) Performance idicators for drainage evaluation and cause analysis. *Proc. 7th Intern. Drainage Symposium.* 8-10 March , Orlando, Florida, pp.355-361.

Hiler, E.A. (1977) Drainage requirements of crops. *3rd. USA National Drainage Symposium*, pp. 127-129.

Ibrahim, S. M. (2000) Depth and quality of the groundwater in North Delta soils. *Proc. 2. Intern. Symposium-Cum-Workshop,*" Egyptian Agriculture in the Future", St. Catherine-Sinai, 20-25 Oct., published by: Germany-Egypt-Arab-Region Inter-Alumni -Net (GEAR).

Ibrahim, S.M. and Khalifa, M.R. (1995) Hydraulic and hydrological properties of clay soil as affected by flood irrigation and open drainage. *J. Agric. Ress. Tanta Univ.* **21** (4), 815.

Kanwar, R.S., Cruse, R.M., Ghaffarzadeh, M., Pecinovsky, K., Karten, D. and Cambardella, C. (1998) Alternative cropping systems to improve the quality of shallow groundwater. *Proc. 7th Intern. Drainage Symposium*, 8-10 March, Orlando, Florida, pp. 538-543.

Oztekin, T., Holdsworth, P.M., Brown, L.C., Kurunc, A. and Rector, D. (1998) Evaluating drainage design parameters for wastewater irrigation application to minimize impact on surface waters. *Proc. 7 Intern. Drainage Symposium*, 8-10 March, Orlando, Florida, pp. 17-27.

Ramirez, J.A. and Finnerty, B. (1996) Precipitation and water-table effects on agricultural production and economics. *J. Irrig. and Drain. Engin. ASCE*, **122** (3), 164.

Rhoades, J.D. and Loveday, J. (1990) Salinity in irrigated agriculture. In:B.A. Stewart and D.R. Nielson (Eds.) *"Irrigation of Agricultural Crops"*. Agronomy No.30. Amer. Soc. Agron. Madison, WI, pp. 1089-1 142.

Richards, L.A. (Ed.), (1954) *"Diagnosis and Improvement of Saline Soils"*. U.S.D.A. Hand Book 60.

(*Received* 4 / 2001)

علاقة تذبذب وملوحة الماء الأرضى بنظم إدارة الارض والمياه

شعبان إبراهيم - محمد كريم - صابر جاهين

قسم الأراضى - كلية الزراعة بكفر الشيخ - جامعة طنطا - مصر.

أجريت هذه الدراسة لتحديد تذبذب وملوحة المياه الأرضى فى أراضى محافظة كفر الشيخ بشمال دلتا النيل وعلاقة ذلك بنظم إدارة الأرض والرى والصرف. حيث تم قياس مستوى الماء الأراضى وملوحته فى ٢٢٧ موقع موزعة بالمناطق المختلفة من المحافظة.

ولقد أوضحت نتائج الدراسة أن الأراضى فى المناطق المدروسة تتميز بمستوى ماء أرضى مرتفع ومتذبذب. وتراوح المتوسط السنوى لمستوى الماء الأرضى تحت كل المحاصيل ما عدا الأرز بين ٣٢-١٥٠ سم بمتوسط عام قدره ٧٧ سم مما يعنى إمكانيه مساهمة الماء الأرضى بجزء من الاحتياجات المائية للمحاصيل المنزرعة. وكانت متوسطات الماء الأرضى فى الموسم الشتوى قدرها ٧, ٧٢ ، ٨ ، ٧٢ ، ٨٢,٤ ، ٠, ٩٩ ، ١٠٩,٨ ، ١٢٤,٧ سم تحت محاصيل البرسيم ، بنجر السكر ، القمح ، الفول البلدى ، الخضراوات الشتوية وأشجار الموالح على التوالى. وكانت القيم المماثلة فى الموسم الصيفى ٣٢,٨، ٩ ,٥٨ ، ١, ٧٠ ، ٧٢,٨ ، ١, ٧٩ ، ٣ ,١١١ سم تحت محاصيل الأرز ، قصب السكر ، الذرة ، الخضراوات الصيفية ، القطن وأشجار الموالح على التوالى.

أوضحت النتائج أيضا أن مستوى الماء الأرضى كان أعمق تحت نظام الصرف المغطى (بمتوسط قدره ١, ٨٥ سم) مقارنة بنظام الصرف المكشوف (بمتوسط قدره ٣, ٧٣ سم). وكانت الاختلافات فى مستوى الماء الأرضى بين أبعاد المصارف المغطاة المختلفة غير واضحة بسبب التباين فى المحاصيل المزروعة ونظام إدارة الرى والظروف المحلية. ولقد تراوح تركيز الأملاح فى عينات الماء الأرضى (Ec values) بين ١-٨ , ١٤ dS / m مع ارتفاع هذه التركيزات فى المناطق الشمالية والشرقية التى تروى بماء مختلط وايضا فى المناطق التى تتميز بمستوى ماء أرضى سطحى.

وبالنسبة لتقييم كفاءة نظم إدارة المياه فلقد أوضحت النتائج انخفاض العمق النسبي للماء الأرضي (RGWD) بسبب الإسراف في الري وزراعة مساحات كبيرة بالأرز. وأن قيم معدل انخفاض مستوى الماء الأرضي (RWTD) كانت أكبر من الواحد الصحيح مما يعني صرف زائد في حالات أبعاد المصارف المغطاة التي تساوي او تقل عن ٣٥م . بينما يلاحظ صرف غير جيد تحت الابعاد ٥٠ ، ٦٠م وأيضا تحت نظام الصرف المكشوف. ويوصى بتطوير نظام الرى في مناطق شمال الدلتا بحيث يضاف المقنن المائي للمحاصيل دون إضافة ماء رى زائد للحقول. ويوصى أيضآ باستعمال نظام الصرف المغطى المطور فى المناطق التى يزرع فيها الأرز فى فى دورة زراعية مع محاصيل أخرى بحيث يمكن التحكم في الماء المنصرف من حقول الأرز حتى لا تسبب فى رفع مستوى الماء الأرضى تحت المحاصيل المجاورة.