Nile Valley University Publications
Nile Journal for Agricultural Sciences (NJAS)
(ISSN: 1585 – 5507)
Volume 02, NO. 01, 2017
http://www.nilevalley.edu.sd

Research paper

Effect of Irrigation Frequency, Furrow Length and Farm Yard Manure on Salt-Affected Soil in Dongola Area

Amal M. Izzel Din[1] and Malik Nasr Malik[2]

[1] *Faculty of Agricultural Sciences, University of Dongola, Dongola, Sudan*
[2] *Faculty of Agriculture, University of Khartoum, Shambat, Sudan*

Corresponding Author: amalizz5@hotmail.com

ABSTRACT

A field experiment was carried out at Dongola University Farm, in Northern State to investigate the effect of irrigation frequency seven days, fourteen days and twenty one days, furrow length five meters (F5) and ten meters(F10) with and without addition of farm yard manure (M1 and M0) on salt leaching under saline-sodic aridisols. The quantity of water applied was estimated according to Jensen and Haise equation where the total water quantity was the same by the end of the experiment. The experiment was designed in a split – plot design, where irrigation frequency was assigned to the main plot and the furrow length (F) and FYM (M) were assigned to the sub-plots. In general, the results indicated that the irrigation frequency of 7 days enhanced salt leaching from the soil depth. Generally, the reduction in ECe due to irrigation frequency was as follows: I7 > I14 > I21. The data obtained indicated that the addition of FYM (M1) significantly decreased ECe and leached it below the soil depth, compared with the plots without FYM (M0). Generally, the salt leaching plots showed a leached zone underlied by a salinized zone. In general, irrigating every 7 days (frequent irrigation), adding FYM at the rate of 5 tons/fed with the furrow length of 5 meters, resulted in the lowest ECe.

Key Words: *Amendments, Ece, farm yard manure, furrow length, irrigation frequency, saline-sodic soil*

تأثير فترات الري، طول السراب وسماد المزرعة على الاراضي المتأثرة بالملوحة بمنطقة دنقلا

امال عز الدين [1] ومالك نصر مالك [2]

1 قسم المحاصيل، كلية العلوم الزراعية، جامعة دنقلا
2 قسم التربة، كلية الزراعة، جامعة الخرطوم

أجريت تجربة حقلية في مزرعة جامعة دنقلا بالولاية الشمالية لدراسة أثر ثلاث مناوبات ري (7، 14 و21 يوم) مع إضافة او بدون اضافة سماد المزرعة في أحواض مسربة بطولين مختلفين للسرابة مع إضافة كميات محسوبة من المياه تم تقديرها بواسطة معادلة جنسن وهيز، حيث كانت كمية المياه ثابتة لكل المعاملات في نهاية التجربة. تمت دراسة أثر كل هذه المعاملات على غسيل محلول تربة شديدة الملوحة. اجريت التجربة وفق تصميم القطع المنشقة حيث وضع مكون الري في القطع الرئيسة وطول السرابة وسماد المزرعة في القطع الفرعية بعدد 36 قطعة (حوض)، 18 منها للسرابات الطويلة و18 اخرى للسرابات القصيرة. أسفرت نتائج التجربة أن مناوبات الري قللت التوصيل الكهربائي لمحلول التربة على النحو التالي 7 يوم > 14 يوم > 21 يوم. حيث أكدت النتائج أن ري التربة كل 7 يوم كان أفضل وتبعه الري كل 14 يوم بينما كان الري كل 21 يوم الأسوأ في غسيل الأملاح. أوضحت النتائج بأن الري بصرف النظر عن المعاملات المختلفة قام بتخفيف التوصيل الكهربائي لمستخلص التربة حتى عمق 50 سم. اما إضافة سماد المزرعة فقد كانت ذات فعالية في غسيل الأملاح حيث وجد أن هنالك فرق معنوي بين الأحواض المعاملة بسماد المزرعة والأحواض التي لم يضاف إليها. كما أفادت نتائج البحث أن طول السرابة كان ذا أثر معنوي حيث أن طول السرابة (5 متر) أظهرت نتائج معنوية مقارنة بطول السرابة (10 متر) في غسيل الأملاح. مما سبق يمكن القول بأن الأثر المتداخل لمناوبة الري كل 7 يوم مع إضافة 5 طن/الفدان سماد المزرعة في أحواض مسربة بطول 5 متر هي الطريقة المثلي لتحقيق أفضل غسيل للأملاح.

Introduction

The accumulation of the excessive salts in the root zone often results in a partial or complete loss of soil productivity. This is a widespread phenomenon in the arid and semi-arid regions of Sudan (Nachtergeale, 1976).

There are three types of salt-affected soils, namely, saline soils, sodic soils and saline – sodic soils. The traditional classification of salt-affected soils has been based on the soluble salt concentration and on the exchangeable sodium percentage (ESP) of the soil (El- Morsy, *et al*., 1991). Saline soils are characterized by a high concentration of soluble salts (more than 4 dS/m) with a soil pH less than 8.5. These soils contain excessive amounts of soluble ions such as Na^{+}, Mg^{++}, Ca^{++}, $K^{+,}$ Cl^{-}, SO_4, CO_3 and HCO_3 (Bohn *et al*., 1985). On the other hand, sodic soils contain excessive amounts of exchangeable sodium with an ESP greater than 15% and pH > 8.5 (USDA, 2009). High values of ESP always adversely affects aggregate stability and hence, resulting in a low soil permeability.

Saline- sodic soils are those of ECe > 4 dS/m and ESP > 15% with a pH > 8.5 (Richards, 1954). Salt-affected soils are found in the Northern part of Sudan, in desert, semi-desert, arid and semi-arid climates. Large areas of Sudan soils are affected to some degree by salinity and/or sodicity.

The increase in both human and animal density encouraged horizontal expansion in agriculture; therefore, the use of these soils for growing crops becomes a necessity

Dongola area is severely affected by desertification and salinization processes. The more productive first terrace soil is intensively used (Izzeldeen, 2002), thus utilization of salt-affected soils has become an important aspect of agricultural development. The upper terrace soils are constrained by salinity and sodicity which restricts crop productivity due to a high osmotic pressure and specific ion effect. In this area, Huntings (1964) and Karouri (1967), cited that considerable variations in salt content and composition exist not only between different sites but also with depth in the same site.

Water resources in Sudan are limited because of the large expansion of the cropped area, particularly, in desert, semi desert, arid and semi-arid regions. However, the scarcity of rainfall led to an increased demand for irrigation water. The situation emphasizes the need for using scientifically sound method for scheduling irrigation water. Thus, the efficient utilization may be realized by the use of salt - tolerant crops, application of soil amendments, addition of fertilizers and proper water management.

Inorganic fertilizers are imported and hence they are very expensive. Thus, there is an increasing trend for the use of agricultural and animal wastes (organic amendments as sources of nutrients). Furthermore, soil organic amendments may improve the soil physical conditions and may thus offer possibility of increasing the efficiency of salt leaching.

Crops vary widely in their tolerance to salinity; salt tolerance of a given crop may vary according to its stage of growth. In general, salts may affect plant growth directly by increasing the osmotic pressure of the soil solution, by accumulation of a certain ion to a toxic level in plant tissues, and by causing nutritional imbalance.

Local barley (*Hordeum Vulgare*) is a potential crop in Dongola area. People use the barley as food and its powder as a medicine. Besides this, the crop is very tolerant to salinity and sodicity.

This research was undertaken to study the effect of irrigation interval, furrow length, and application of farm yard manure on salt leaching in Dongola area.

Materials and Methods

The study area climate

The study was conducted in Dongola area which is true desert with extremely high temperatures and radiation in summer, low temperature in winter, scarce rainfall, and high wind speed. The diurnal range of temperature is wide all the year. The mean maximum and minimum temperatures are 36.8 and 19.5ºC, respectively. Temperatures as high as 49ºC are not uncommon in the period extending from April to June. In winter, temperatures as low as 1.0ºC have been recorded. The climate is hyper arid with a vapor pressure of only 10.8mb and a relative humidity of less than 20% with a mean bright sunshine duration of 10.5 hours (at 87% of the possible hours). Clouds are generally rare. Solar radiation is as high as 25.88 $MJ/m^2/day$ in May. Rainfall is scarce with a mean annual of 12.3mm. Wind prevails from the North at a mean speed of 15.7km/hr (Izzel Deen, 2002).

Physiography

Dongola area, consists of a basement complex of precambrian metamorphic rocks overlain by the Nubian sandstone which is known for it's abundant ground water (Izzel Deen, 1983) observed out crops of basement complex just North of Kerma town. Alluvial deposits dominate the flood plains along the Nile banks. Away from this bank, sand dunes rest upon smooth ground sloping gently towards the Nile. The land is flat due to wind erosion and the nature of the underlying rocks (Andrew, 1947). The geomorphology of the area is characterized by sand and wind hammocks. In general, in Dongola, the soil area is divided into two main groups; soils of the recent flood plain and soils of the high terrace (Karouri, 1978).

Soil of the study area

A profile was dug in the experimental area and described according to the standard soil survey procedures. The physical and chemical properties of this profile are reported in Table (1).

Profile Description

- Parent material: Nile alluvial deposits.
- Drainage: well drained.
- Soil moisture condition: dry.
- Depth of ground water table: 8 meters.
- Presence of erosion: wind erosion.
- Presence of surface stones: (Nil.)
- Presence of salt or alkali: common $CaCO_3$ white concretions.
- Human influence: virgin land, dark with wheat fields nearby.

0-10cm: Brown to dark brown (10 YR 4/3) moist and dry, loam to sandy loam, slightly sickly and slightly plastic fine granular structure, friable moist; soft dry; few fine tubular pores; calcareous matrix; abrupt smooth boundary; pH 8.2.

10-40cm: Brown to dark brown (10 YR 4/3) moist and dry, sandy clay loam, moderate to medium and fine sub-angular blocky; sticky and plastic wet; friable moist; hard dry; few fine tubular pores; common $CaCo_3$ calcareous; smooth boundary; pH 7.7.

40-60cm: Grayish brown (10 YR 4/3) moist and dry; sandy clay loam; moderate; fine sub-angular blocky; sticky; plastic wet; firm moist; hard dry; few fine pores; sand grains; gray $CaCO_3$ nodules; gradual smooth boundary; pH 7.8.

60-75cm: Grayish brown (10 YR 5/2) moist; loam, weak, coarse, medium and fine sub-angular blocky; slightly sticky; plastic; firm moist; hard dry; few tubular pores; many $CaCO_3$ nodules; very strong calcareous with smooth boundary; pH 9.5.

75-120cm: Light yellowish brown (10 YR 6/4) dry; dark brown to brown (10 YR 4/5) moist; friable; sandy loam; massive; slightly sticky, slightly plastic; wet friable moist; hard dry; few $CaCO_3$ white concretions; slightly calcareous; pH 7.3.

140-170cm: Yellow (10 YR 7/6) dry; yellowish brown (10 YR 5/6) moist; sand; single grain; non sticky and non plastic; loose moist; loose dry; non calcareous; pH 7.4.

Layout of the experiment

A field experiment was carried out, in Dongola University Farm at Elselaim, on the eastern bank of the Nile. The experiment was undertaken to investigate the effect of irrigation frequency (I), furrow length (F) and filed yard manure, FYM (M) on ECe. The treatments consisted of three irrigation intervals; 7, 14 and 21 days, two furrow lengths, 5 m- long (F_5) and 10 m- long (F_{10}) with and without addition of FYM ($M_1$and M_0, respectively). The experiment was arranged in a spilt-plot design, where irrigation interval (frequency) was assigned to main plots (10x15m), each experiment was divided into four subplots. Thus, it was consisted of nine main plots and 36 subplots. The main plot (10×15m) was separated by 2m-wide path. The whole area was ploughed to 30 cm depth. Each main plot (10×15m) was consisted of two short furrow (F_5) plots (5×5m) and two long furrow plots (5x10m). The test crop was local barley (*Hordeum Vulgare*).

Land Preparation

Experimental area was ploughed to the depth of 30 cm, then the span leveler was used for leveling the area, then a tool bar was used for ridging to give a standard ridge spacing of 80 cm for the furrow.

Soil Sampling

Two sets of soil samples were taken from each plot, one before sowing and a second set at harvest. Soil samples of approximately 2kg were collected from depths of 0- 20, 20- 40, 40- 60, 60- 80 and 80- 100 cm soil depths. Total number of samples collected was 720 soil samples. The samples were air-dried, crushed and passed through 2-mm sieve and kept in labeled bags for physical and chemical analysis.

For each soil depth, clots each of approximately 5 cm in diameter were taken from the same soil depths for bulk density determination.

Irrigation treatments

A predetermined quantity of water (Qi) was delivered to the sub plots using the 5-cm throat width Parshall flume in the experiment. The water quantity was estimated by the following relationship:

$$\mathrm{Qi(mm)} = \frac{\mathrm{K_c ET_p \times F \times 100}}{\mathrm{E_i}}$$

Where:

K_c: crop coefficient

ET_p: potential evapotranspiration (mm/day)

F: irrigation frequency

Ei: irrigation application efficiency assumed as 70%

ET_p was estimated by the following Jensen and Haise (1963) equation;

$$\mathrm{ET_p = C_T(T - T_x)R_s} \text{ (ETp has the same units as } \mathrm{R_s}\text{)}$$

$$\mathrm{C_T} = \frac{1}{\mathrm{C_1 + 7.6 \times C_H}}$$

$$\mathrm{C_H} = \frac{\mathrm{50mb}}{\mathrm{C_2 - C_1}}$$

$$T_x = -2.5 - 0.14(e_2 - e_1) - \frac{E}{550}$$

Where:

T = mean air temperature, ºC.

R_s = short wave incoming solar radiation

e_2 is the saturation vapor pressure of water in mb at the mean monthly maximum air temperature of the warmest month in the year (long term climatic data), and e_1, is the saturation of vapor pressure of water in mb at the mean monthly minimum air temperature of the warmest month in the year.

$$\mathrm{C_1} = 38 - \frac{\mathrm{2E}}{305}$$

Where:

E= the site elevation in m.

Soil analysis

All determinations were carried out according to the standard method outlined in USDA (2009). The following determinations were made for each sample at the laboratory of Agric. Research Station of Dongola: saturation percentage, moisture content, pH, electrical conductivity (ECe), soluble cations, (Ca and Mg), Na by flame photometer, sodium adsorption ratio (SAR), exchange sodium percentage (ESP) and mechanical analysis. Soil bulk density was determined using the clod method (Black, 1962).

Results and discussion

The effect of irrigation frequency on ECe

Table (2) shows the effect of irrigation frequency (I) on the initial ECe for the experiment at depth 0 – 20cm. The irrigation frequency reduced the initial ECe by 73.2, 68.5 and 52.0% for irrigation frequency at 7 days, 14 days and 21 days, respectively. The statistical analysis of the data showed that there was no significant difference between I_7 and I_{14}, but showed a significant difference (P=0.05) between I_7 and I_{21} and I_{14} and I_{21}.

Effect of irrigation frequency on the initial ECe for at the depth 20-40cm presented in Table (3). The effect of the irrigation frequency on ECe at this depth has the same trend as top soil (0 – 20cm). The reduction in the initial ECe is as follows: $I_7 > I_{14} > I_{21}$, respectively. The reduction in the initial ECe was 61.1, 53.0 and 20.7% when irrigated every 7, 14 and 21 days, respectively. In general, salt leaching was increased with decreasing irrigation frequency. This may be attributed to the fact that the frequent irrigation reduced the soil matric suction and alleviate both osmotic and water potential (Hillel, 1982). These results are in agreement with the findings of Wagenet *et al.* (1980), Abdel Rahim (1985), Ali (1987), Ahmed (1995) and Fardad and Shirdeli (1996).

Table 2: Mean electrical conductivity (dS/m) as affected by irrigation frequency, furrow length and FYM at 0- 20 cm soil depth at the end of the experiment

Irrigation frequency (days)	Initial ECe (dS/m)	Treatment				Mean
		F_5		F_{10}		
		M_0	M_1	M_0	M_1	
I_7	51.52	13.00	11.00	15.21	16.00	13.80[b]
I_{14}	51.52	15.00	13.90	18.91	17.20	16.25[b]
I_{21}	51.52	25.00	20.87	27.00	26.00	24.72[a]
FYM (mean)	51.52	17.77	15.25	20.37	19.73	
Furrow mean	51.52	16.38[b]		20.05[a]		
CV	16.95					

I_7, I_{14} and I_{21} denote irrigation frequency at 7, 14 and 21 days, respectively.
F_5 and F_{10} represent furrow length 5 and 10 meter long, respectively.
M_0 and M_1 represent 0 and 5 tone/feddan - farm yard manure, respectively.
NS, S^*, S^{**} represent non significant, and significant at 0.05 and 0.01 level of probability, respectively.
Main irrigation frequency (I) effect $LSD_{0.05}$ = 2.66
Main furrow length (F) effect $LSD_{0.05}$ = 2.17
Main farm yard manure (M) effect $LSD_{0.05}$ = 2.17
Interaction (I × F) effect = NS
Interaction (I × M) effect = NS
Interaction (F × M) effect = NS
Interaction (I × F × M) effect = NS

Table 3: Mean electrical conductivity (dS/m) as affected by irrigation frequency, furrow length and FYM at 20-40cm soil depth at the end of the experiment

Irrigation frequency (days)	Initial ECe (dS/m)	Treatment				Mean
		F_5		F_{10}		
		M_0	M_1	M_0	M_1	
I_7	34.25	17.10	14.21	18.90	19.70	17.48[b]
I_{14}	34.25	18.20	16.40	19.70	19.70	18.50[b]
I_{21}	34.25	27.00	22.00	27.33	27.67	26.00[a]
FYM (mean)	34.25	20.76	17.53	21.97	22.35	
Furrow mean	34.25	19.15[b]		22.17[a]		
CV	9.22					

Abbreviations as explained in Table (2)
Main irrigation frequency (I) effect $LSD_{0.05}$ = 1.61
Main furrow length(F) effect $LSD_{0.05}$ = 1.32
Main farm yard manure (M) effect $LSD_{0.05}$ = 1.32
Interaction (I × F) effect = NS
Interaction (I × M) effect = NS
Interaction (F × M) effect = S^{**}
Interaction (I × F × M) effect = NS

Table (4) showed the effect of irrigation frequency (I) on ECe at (40 – 60cm) depth. It is evident that the effect of I on this layer was not as marked as that on the top layers. This may be due to the slow water movement in these layers due to increase in ESP and the bulk density with depth, hence the ECe increased by 27.8, 28 and 34.2% when irrigated every 7, 14 and 21 days, respectively. However, there was no significant difference among the three irrigation frequencies in this layer.

Table 4: Mean electrical conductivity (dS/m) as affected by irrigation frequency, furrow length and FYM at 40-60cm soil depth at the end of the experiment

Irrigation frequency (days)	Initial ECe (dS/m)	Treatment				Mean
		F_5		F_{10}		
		M_0	M_1	M_0	M_1	
I_7	21.76	20.91	20.41	39.20	30.67	27.80[a]
I_{14}	21.76	20.00	20.00	40.50	30.90	27.85[a]
I_{21}	21.76	17.33	17.89	39.70	41.90	29.21[a]
FYM (mean)	21.76	19.41	19.43	39.8	34.49	
Furrow mean	21.76	19.42[b]		37.15[a]		
CV	10.77					

Abbreviations as explained in Table (2)
Main irrigation frequency (I) effect $LSD_{0.05}$ = 2.58
Main furrow length (F) effect $LSD_{0.05}$ = 2.11
Main farm yard manure (M) effect $LSD_{0.05}$ = 2.11
Interaction (I × F) effect = S^{**}
Interaction (I × M) effect = S^{*}
Interaction (F × M) effect = NS
Interaction (I × F × M) effect = NS

Table (6) presents the effect of irrigation frequency on (80–100cm) depth for the experiment. In this layer, the initial ECe increased by 174.7, 198.3 and 148.1% for I_7, I_{14} and I_{21}, respectively.

The ECe distribution can be divided into two zones, leached zone from top to 50cm depth and accumulation zone, from 50cm up to 100cm depth and the efficiency of leaching decreased with the increasing of soil depth. This may be due to decrease in water movement with the soil depth due to increase in clay content and the bulk density with increase in soil depth (Table 1).

The effect of furrow length (F) on ECe

The effect of furrow length on ECe for 0 - 20cm and 20 - 40cm depth for the experiment, is shown in Tables (2) and (3). The effect of furrow length on ECe is statistically significant (P=0.05). The ECe values at the (0-20cm) depth were decreased by 68.2 and 61.2% at furrow length five meters (F_5) and furrow length ten meters (F_{10}), respectively.

For (20–40cm) depth, ECe values were decreased by 44 and 32.3% for F_5 and F_{10}, respectively.

Tables (4,5 and 6) show the effect of furrow length on the ECe for (40-60cm), (60–80) and (80–100) soil depth for the experiment. The effect of furrow length on ECe is statistically significant (P=0.05) for all. The ECe values were decreased by 10.9% at F_5 and increased by 70.7% at F_{10}.

For (60 – 80cm) depth, the initial ECe was increased by 259.5% at F_5 and 128.8% at F_{10}.

The initial ECe increased in the 80–100cm depth by 146.3% for F_5 and by 201% for F_{10} for the experiment. Generally, the reduction in ECe was in the following order: $F_5 > F_{10}$.

It is clear that the furrow length (F_5) was more effective in salt leaching than the furrow length (F_{10}). This is may be due to the fact that short furrow conserves more water and minimizes unnecessary deep drainage (Izzel Din, 1995). Long furrow results in deep percolation losses and erosion in the upper ends of furrows (Schwab *et al.*, 1966). These results were in agreement with the findings of Mohamed (2002).

The effect of FYM (M) on ECe

Tables (2) and (3) show the effect of FYM on the initial ECe for (0–20cm) depth and (20– 40cm) depth for the experiment. Addition of FYM, significantly (P = 0.05) affected salt leaching and reduced ECe by 63.1 and 66% for plots without FYM (M_0) and plots received 5 ton/ fed. FYM (M_1), respectively.

Tables (4, 5 and 6) show the effect of addition of FYM on ECe at the (40–60cm), (60–80cm) and (80–100cm) soil depth. The initial ECe was affected by the application of M_1 where it was increased by 36 and 24% for M_0 and M_1, respectively. Further, the data showed that the (60–80cm) and (80–100cm) soil depth followed the same trend as in depth (40–60cm) and the initial ECe increased by 51.1 and 52.1% for M_0 and M_1, respectively. The initial ECe of (80 – 100cm) depth was increased in the experiment by 26.9 and 37.5% for M_0 and M_1, respectively.

In general, as the results showed, application of FYM, significantly (P = 0.05) affected salt leaching and ECe distribution in the soil profile which showed a top leached zone and a salt accumulation zone.

It is clear that the plots received FYM (M_1) resulted in the best salt leaching than those without FYM (M_0). These results were in agreement with the findings of Poonia and Bhumbla (1974); Meek *et al.* (1979); Parsad and Singh (1980) and Izzel Deen (1995). This may be due to the fact that FYM improved the physical and chemical conditions of soil, protect soil water from evaporation and enhanced the stability of the soil aggregates (Mustafa and Abdel Magid, 1981).

The combined effect of furrow length (F) and FYM (M) on ECe

Table (2) shows the combined effect of furrow length ten meters (F_{10}) and five meters (F_5) with the addition of 5 ton/ fed of FYM to each furrow length (F_5M_1 and $F_{10}M_1$) and without the addition of FYM (F_5M_0 and $F_{10}M_0$), at 0 – 20cm depth for the experiment on the initial ECe. The combined effect of F_5M_1 and $F_{10}M_1$, reduced the initial ECe by 70.4 and 61.7%, respectively.

In general, the combined effect of FYM and furrow length reduced the initial ECe in the following order: F5M1 > F5M0 > F10M1 > F10M0.

Table (3) presents the combined effect of furrow length and addition of FYM on ECe at 20 – 40cm depth for the experiment. It is clear that in this depth, the combined effect of (F) and (M), reduced the initial ECe by 48.8 and 34.7% for F5M1 and F10M1, respectively, for the experiment.

Table (5) presents the effect of irrigation frequency on initial ECe at 60 – 80cm depth. In this depth, salt leaching followed the same trend as in 40 – 60cm depth and the ECe values increased by 191.6, 204 and 185.3% when irrigated every 7, 14 and 21 days, respectively, for the first experiment. However, there was no significant difference among the three irrigation frequencies.

Table (6) presents the effect of irrigation frequency on (80-100) soil depth for the experiment, in this layer, the initial ECe increased by 174, 7,198.3 and 148.8% for I7, I14 and I21, respectively.

Table (4) shows the effect of combined treatments, F_5M_1 and $F_{10}M_1$ at depth (40 – 60cm). The data showed that F_5M_1 reduced the initial ECe by 10.7%, whereas $F_{10}M_1$ increased ECe by 58.5% for the experiment.

Tables (5) and (6) show the combined effect of furrow length (F) and FYM (M) on ECe of (60 – 80cm) and (80 – 100cm) depth for the experiment. The combined effect of F_5M_1 and $F_{10}M_1$ both increased ECe by 223.2 and 170.1%, respectively, for (60 – 80cm) depth by the end of the experiment. At (80 – 100cm) depth for the experiment, the combined effect of furrow length and FYM increased ECe by 185.1 and 252% for F_5M_1 and $F_{10}M_1$, respectively. In general ECe increased in this depth in the following order: $F_{10}M_1 > F_5M_1 > F_{10}M_0 > F_5M_0$.

Table 5: Mean electrical conductivity (dS/m) as affected by irrigation frequency, furrow length and FYM at 60-80cm soil depth at the end of the experiment

Irrigation frequency (days)	Initial ECe (dS/m)	Treatment				Mean
		F_5		F_{10}		
		M_0	M_1	M_0	M_1	
I_7	17.56	70.83	39.50	43.90	50.60	51.21[a]
I_{14}	17.56	71.50	65.49	25.90	51.27	53.54[a]
I_{21}	17.56	66.07	65.30	28.60	40.40	50.09[a]
FYM (mean)	17.56	69.46	56.76	32.80	47.42	
Furrow mean	17.56	63.12[a]		40.17[b]		
CV	7.75					

Abbreviations as explained in Table (2)
Main irrigation frequency (I) effect $LSD_{0.05}$ = 3.38
Main furrow length (F) effect $LSD_{0.05}$ = 2.76
Main farm yard manure (M) effect $LSD_{0.05}$ = 2.76
Interaction (I × F) effect = S^{**}
Interaction (I × M) effect = S^{**}
Interaction (F × M) effect = S^{**}
Interaction (I × F × M) effect = S^{**}

Table 6: Mean electrical conductivity (dS/m) as affected by irrigation frequency, furrow length and FYM at 80-100cm soil depth (cm) at the end of the experiment

Irrigation frequency (days)	Initial ECe (dS/m)	Treatment				Mean
		F_5		F_{10}		
		M_0	M_1	M_0	M_1	
I_7	11.76	28.00	29.60	29.00	42.60	32.30[a]
I_{14}	11.76	25.00	40.50	31.90	42.90	35.08[a]
I_{21}	11.76	20.17	30.50	27.23	38.80	29.18[b]
FYM (mean)	11.76	24.39	33.53	29.37	41.43	
Furrow mean	11.76	28.96[b]		35.41[a]		
CV	10.61					

Abbreviations as explained in Table (2)
Main irrigation frequency (I) effect $LSD_{0.05}$ = 2.89
Main furrow length(F) effect $LSD_{0.05}$ = 2.36
Main farm yard manure (M) effect $LSD_{0.05}$ = 2.36
Interaction (I × F) effect = NS
Interaction (I × M) effect = NS
Interaction (F × M) effect = NS
Interaction (I × F × M) effect = S^{*}

Conclusions

In this study, the effect of irrigation frequency, furrow length and FYM was investigated. The results indicated that the short frequency irrigation (7 days), with the application of 5ton/fed FYM and the furrow length (F_5) were found to be good practices to enhance leaching of salts.

References

Abdel Rahim, H.A. (1985). The effect of irrigation regime and some soil amendments on salt redistribution and forage (*Sorghum bicolor*) grown on a saline–sodic clay soil. M.Sc. thesis. University of Khartoum.

Ahmed A.B. (1995). Impact of soil water management on salt leaching and forage Sorghum growth in Shambat soil. M.Sc. thesis. University of Khartoum.

Ahmed, S.H. (1987). Effect of two soil amendments on wheat yield grown on high terrace soil in Eddamer area. A. R. C. IFAD. Annual report. Medani Sudan.

Ali, F.M. (1987). Wheat research and production in Sudan. Agricultural research corporation, Wad Medani. Sudan Tech. Bull. No.57

Andrew, G. (1947). Memorandum on desert creep Sudan. Gov. Rep. Soil cons. Commi.

Ayers, R.S. and Westcot, D.W. (1976). Water quality for agriculture irrigation and drainage paper No. 29, FAO, Rome, Italy.

Bhatangar, V.K.; Kundus, S. and Vedprakash, S. (1992). Indian J. Agric. Sci. 62: 212.

Black, C.A. (1962). Methods of soil chemicals analysis part I and part II. Macmillan Publishing company Inc.

Bohn, H.L.; McNeal and O'connor, G.A. (1985). Soil chemistry, 2nd ed., John Wiley and Sons.

Dahab, M.H. (1984). The effect of irrigation quantity and frequency and some soil amendments on salt leaching in a saline-sodic clay soil. M.Sc. thesis, University of Khartoum. .

EL-Morsy, E.A; Malik. M, and Letey. (1991). Interactions between water quality and polymer treatment on infiltration rate and clay migration. Soil technology. 4: 221-231.

Fadul, E.M. (2003). The impact of irrigation and FYM on the productivity of wheat (*Tritichum aestivum*) on a salt – affected soil in Elseleim, M.Sc. thesis, University of Khartoum.

Fardad. H. and Shirdeli. A.C. (1996). Effect of irrigation frequency on barley growth and grain yield. Irrigation J. of Agric Sci. 26: 1, 23-31.

Hillel, D. (1982). Soil water: content and potential introduction to soil physics. Academic press: 57.

Huntings Technical Services (1964). Roseires soil survey. Report No. 5, Ministry of Agriculture, Sudan.

Izzel Deen, S.I.M. (1983). Land degradation in Kerma basin. M.Sc. thesis, University of Khartoum, Sudan.

Izzel Deen, S.I.M. (2002). Impact of irrigation method and plough depth on wheat productivity on a saline – sodic soil in Dongola, Sudan, Ph.D. Thesis, University of Khartoum.

Izzel Din, A.M. (1995). The impact of irrigation and organic amendment on salt leaching and soil water conservation of a saline-sodic clay soil and A sand. Shambat Lib. MSc. Thesis.

Jensen, M.E. and Haise, H.K. (1963). Estimating evaporanspiration from solar radiation. Proc Am .Soc. CN. Enger., J. 89: 5-41.

Karouri, M.O.H. (1967). Annual report of research division. Ministry of Agriculture, Sudan.

Karouri, M.O.H. (1978). The effect of soil salinity on the productivity of arid lands, with special reference to the Sudan. Proc. of Khartoum workshop on Arid lands management. 49 – 54

Meek, B.D.; Graham, L.E.; Donoven, J.J. and May Berry, K.S. (1979). Phosphorus availability in calcareous soil after a high adding rate of animal manure. Soil–Sci. Soc. Am. Proc. 43; 741-744.

Mohamed, M.S. (2002). Appraisal of the long furrow irrigation system in Kenana sugarcane plantation, M.Sc. Thesis, University of Khartoum.

Mustafa, M.A. and Abdelmagid, E.A. (1981). The effect of irrigation interval, urea–Na, gypsum on salt leaching redistribution in highly saline sodic montmorillonite clay soil under forage sorghum. Soil Sci. 132(4): 308.

Nachtergeale, F.O.F. (1976). Studies on saline sodic soils in Sudan. FAO/UNDP. Project for strengthening the soil survey administration. SUD/71/553. Technical Bulletin N. 24-May 1976. Wad Medani, Sudan.

Paliwal, K.V. (1977). Nutrient requirement of salt – atech soil –proceeding indo-Hungarian seminar "management of salt–affected soil S. S. R. I., Karnal, India.p. 202-218.

Parasad, B., and Singh, A.P. (1980). Changes in soil properties with long–term use of fertilizer, lime and farm yard manure. J. Indian: Soc. Soil Sci. 28: 465.

Poonia, S.R. and Bhumbla, D.R. (1974). Effect of FYM on the yield, chemical composition and calcium availability from gypsum and calcium and carbonate to barley in a saline alkali soil. J. Ind. Soc. Soil Sci. 22: 371.

Schwab, G.C.; R.K. Frevert, T.W.; Edminster, and K.K. Barnes (1966). Soil water conservation engineering. 2nd ed. John Willy and Sons. New York.

Sharma, H.L.; Singh, C.M. and Model, S.C. (1987). Use of organic fertilizers in rice wheat crop sequence. Indian J. Agric. Sci. 57 (3), 163-168.

USDA (2009). Soil survey filed and laboratory methods manual. USDA, USA, 405 pages.

Wagenet, R.J.; Eamplieu; W.F; Bamatrat, A.M.; and Turner, D.L. (1980). Salinity, irrigation frequency and fertilization effects on barley growth. Agron. J. 72: 969-974.

Table 1. The physical and chemical properties of a typical soil profile from the experimental site

Depth (cm)	ECedS/m	pH	Soluble cations (meq/l)				Soluble anions						S.P %	Particle size distribution %				ESP %	CEC Meq/100g soil	$CaCO_3$	B.D g/cm^3	SAR
							%		(meq/l)													
			Ca^{++}	Mg^{+}	Na^{+}	K^{+}	N%	P%	CO_3^-	HCO_3^-	Cl^-	SO_4^-		Clay	Silt	Sand	Fine sand					
0-10	23.9	8.5	20	5.3	212	1.15	0.08	0.0018	-	19.2	45	173.3	40.5	19.0	10.1	37.2	33.7	58.8	19.0	8.42	1.54	59.55
10-40	26.8	7.7	28	7.8	231	1.17	0.014	0.0015	-	10.9	190	66.0	39.8	21.9	13.9	22	42.2	54.1	24.0	7.20	1.51	54.61
40-60	27.3	7.8	19.2	7.9	245	1.16	0.002	0.012	-	12.5	130	129.8	52.9	29.5	21.5	16.1	32.9	66.0	30.0	8.51	1.76	66.58
60-75	30.2	9.5	16.5	6.0	269	1.01	0.002	0.028	-	11.8	80	199.8	45.9	25.2	29.9	5.0	39.9	78.5	24.0	8.32	1.77	80.30
75-120	20.8	7.5	9.4	6.1	192	0.18	0.005	0.007	-	18.4	91	98.3	48.4	23.1	25.2	4.2	47.0	67.8	26.0	6.21	1.54	69.06
120-140	21.9	7.3	7.2	5.3	205	1.06	0.009	0.019	-	16.5	110	91.2	42.3	20.5	15.5	4.0	60.0	80.1	28.0	4.29	1.54	82.0
140-170	8.2	7.4	3.4	4.8	70.9	1.09	0.002	0.007	-	10.4	35	33.7	32.0	-	-	29.1	70.9	35.6	3.4	1.90	1.50	35.10