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ORIGINAL ARTICLES

Improving the Properties of Saline and Sodic Soils through Integrated Management Practices

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ABSTRACT

The study was intended to investigate the suitable management practices required to maximize utilization of saline-sodic marginal lands for the purpose of increasing fodder production and thereby improve mixed farming system in Khartoum state. Detection of salinization and management of its severity and extent particularly in its early stages is vital for agricultural production. The management of saline-sodic soils requires a combination of agronomic, cultural and socio-economic factors. This study particularly considered the integrated impact of all management parameters (irrigation, tillage and addition of amendments) and their interrelated functionality rather than selecting two or single factor as usually done in similar earlier research. Split plot design was chosen to test the impact of irrigation intervals (I_7, I_{14} and I_{21} days), tillage operation (with respect to tillage depth and soil inversion using chisel-harrow, plow-harrow and harrow only) and addition of organic amendments. Irrigation interval was significantly increased fresh yield, plant height and root length. The results indicate that the effect of irrigation intervals on fresh yield, plant height and root length was greater than the effects of tillage implementation and organic amendments. The application of chisel-harrow was highly significant in increasing fresh yield and root length. At 7days irrigation intervals the application of harrow only and chisel-harrow operation significantly increased plant height. The addition of organic manure was highly significant in increasing fresh yield and plant height. However, the differences were found highly significant between irrigation intervals and organic amendment.

Key words: Saline-Sodic soils; salinity; sodicity; management practices.

Introduction

The existing scattered soil survey information indicates a wide distribution of the saline and/or sodic soils within Khartoum State, but some prominent locations could be singled out. These occur south of Khartoum between the Blue and White Niles (e.g. Soba scheme) and on the eastern and northern bank along the river Nile (e.g. Al Selait and Kuku schemes). Due to recent expansion of agriculture into marginal lands, the saline and/or sodic soils are continuously increasing. Although agricultural research on improving the performance of these soils start earlier, but they are of limited scope and confined to studying individual management factors rather than investigating the combined and interaction effects of the management multiple factors.

The limited research which was conducted on salt affected soils of Shambat and Soba research station showed the beneficial effects of land preparation, irrigation frequency and organic amendments on management and production of forage Sorghum and Lucerne in salt affected soils (Karuri et al., 1980; El Amin 1980, Mustafa and A/Magid 1982; Gabir, 1984; Ahmed, 1995; Mustafa, 2007). The current agricultural land use in Khartoum state indicates that fodder crops dominate the commercial mixed farming system. The increasing demand for fodders in Khartoum state has led to intensification of fodder production and expansion of cultivation into marginal salty and sodic soils of the upper terraces. The existing management practices to cultivate these problematic soils depends mainly on the local experience of the farmers, individual efforts from some professional farm managers and limited extension support from local extension officers.

The objectives of the study include characterization of saline-sodic soils of upper terraces of Khartoum state in order to find out factors that limit fodder productivity and as well to investigate the impact of some

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management practices (namely: amendments: chicken manure and farm yard manure, three tillage methods: chisel-harrow, disc plow-harrow and disc harrow, three irrigation intervals: (I_7, I_{14} and I_{21}days) on yield and yield components of Abu Sabien fodder crop (fresh yield, plant height, root length) and on soil characteristics (salt redistribution: EC_e, SAR, ESP, and pH).

Materials and Methods

Materials:

1. Study area:

Aselait area is part of the old alluvial superficial deposits which are thought to be laid down by Blue Nile and River Nile during the Quaternary period. These deposits have varying thicknesses with the solid geology underneath of Nubian sandstone and Basement Complex rock. Windblown eroded sandstone particle mixed with fine dust particles (Loess) are often deposited and accumulated on topsoil all over the area. These windblown dark yellowish brown deposits are reworked by runoff water during rainy seasons and found as an over wash on top of the profile in most parts of the scheme.

The study area falls in the semi-desert climate with summer rains, warm winter. The climate is hot almost throughout the year, except the cooler short winter season (December, January). Mean annual temperature is 28 ^{o}C. Average maximum temperature in the hottest months (April-June) is range from 40 ^{o}C to 42 ^{o}C, while the minimum temperatures in that period are between 21 ^{o}C and 26 ^{o}C. During the winter (December-January) minimum temperature reaches 13 ^{o}C. Relative humidity ranges from 30- 40 % during January- February, decreases to 20-27 % in March- June and increases 30-45% from July to December. The average annual rainfall is about 100 mm, with most of the rain falling in July-August. The amount is quite variable and distribution is rather erratic and irregular.

2. Experimental Plots and treatments:

Two different field plots of an area of 2 feddans each at Aselait scheme were chosen to conduct the field experiment during season 2006. One experiment was carried out at canal 17, and delineated by lat 15 35.269 N and long 32 40.019 E, and classified as non saline and non sodic soil (Adam et al 1974), while the other was carried out at canal 15, and delineated by lat 15 35.398 N and long 32 41.389 E. The soils were classified as saline sodic soil cracking clay soils. Two types of organic amendments - chicken manure (CHM) and farm yard manure (FYM) - were used in the research work at the rate of 1 tone/ feddan each. As well one chemical amendment was used (urea 46% N) at the rate of 50 kg/ feddan. The main source of water is the Blue Nile water in Aseleit irrigation canal. This water is classified as good quality (Mustafa, 1973). The tillage implements used in this research are Chisel plow; Disc plow; Harrow; and Rigger.

Methods:

Two separate and spatially isolated field plots were used to compare the effect of amendments, tillage operation and irrigation frequency on Abu Sabien (*Sorghum bicolor* L.) production grown in saline sodic soil with the non saline sodic soil using the same treatments. The experiment consists of two organic amendments: chicken manure (CHM) and farm yard manure (FYM), and three tillage operations: chisel-harrow (0 – 20 cm depth), disc plough-harrow (0 -15 cm depth) and disc harrow only (0 – 5 cm depth), and three irrigation intervals: 7 days, 14 days and 21days. Each treatment was replicated four times. The experiment was arranged in split-split-plot design, where manure were assigned main plot (45×45m), each of which was divided in to three sub-plots (15×45m) and each sub plot was divided in to three sub-sub-plots (7.5×15m). The main plots were 3 meter apart to prevent lateral water movement.

In all treatments the land was leveled and ridged at 80 cm spacing and prepared at three levels as follows: a) Chiseling to a depth of 0 – 20 cm; b) Plowing to a depth of 0 – 10 cm; c) Harrowing to a depth of 0 – 5cm. Application of amendments: Each of the two organic amendments was applied at a rate of one tonne/ feddan while the chemical amendment was added at the rate of 1 N urea/ feddan to all treatments. Planting methods: Abu Sabien was broadcasted in 26 April 2006 with a seed rate of 50 kg/feddan and ridges. Irrigation treatments: First irrigation was applied immediately after sowing to all treatments to promote emergence and establishing the crop before the test of the different irrigation regimes. The seventy five field plots were irrigated on 26 April 2006. The amounts of irrigation water were applied as practiced by farmers in the study area.

Three sets of irrigation scheduling were used in the field plots; the first one is the 7 days irrigation intervals, applied 12 times and the second one is the 14 days irrigation intervals, applied 6 times whereas the third one is the 21 days irrigation intervals, applied 4 times.

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1. Soil Samples collection and laboratory analysis:

Two soil pits were opened, one in each experiment, and was studied in the field and described and 11 soil samples were collected for the routine analysis before land preparation. Another soil samples from two depths (0 – 30 and 30 – 60 cm) were collected by an auger from each sub-plots of each treatment immediately before sowing for determination of the soil pH, salinity and sodicity distribution. The soil samples were air dried and crushed using a wooden mortar and pestle and sieved to pass a 2mm sieve. Soil physical and chemical analyses for the samples were carried in the laboratories of the Department of Soil and Environment, Faculty of Agriculture, Khartoum University.

2. Plant Measurements:

a) Yield: Abu Sabien was manually harvested from one square meter using sickle and immediately weighed in the field. The cutting of crop was made after 90 days for all irrigation intervals.
b) Plant height: Plant heights of nine randomly selected plants from each sub-plot were measured in cm, before harvesting.
c) Root length: The field was ponded with water, and then root lengths of eighteen randomly selected plants from each sub plot were uprooted and measured in cm after 90 day

3. Statistical analysis:

Data obtained were analyzed by computer using the statistical package for sociological studies (SPSS) program using simple statistical analysis. Analysis of variance (ANOVA) was also conducted to test for significant difference between means. Means that were significantly different were separated using the least significant diferent test (LSD).

Results and Discussions

Salinity and Sodicity Levels:

These soils mostly contain sodium chloride in the upper part of the soil profile and consist of a mixture of sodium chloride and sodium sulphate in the lower horizons where calcium sulphate contributes to soil salinity. The soluble salts are of moderate amounts in the upper parts of the profile and increase to high concentration with depth. Exchangeable sodium percentages for the investigated sites are high. This high sodicity is reflected in the formation of Natric horizon (soil layer with high Na concentration) coupled with prismatic structure. The soil is moderately saline and moderately sodic (Nachtergaele, F.O., 1976). Salinity tends to increase with depth, and sodicity is associated with salinity. As depicted in figure 4.1 sodicity levels are accumulated around the 30 to 90 and 130 cm zone while salinity levels are around the depth of 40 to 130 cm. Similar values were reported by Nachtergaele, (1976). To reduce the hazardous effects of both salinity and sodicity proper management practices are critically needed when cultivating these lands (Doka, 2002).

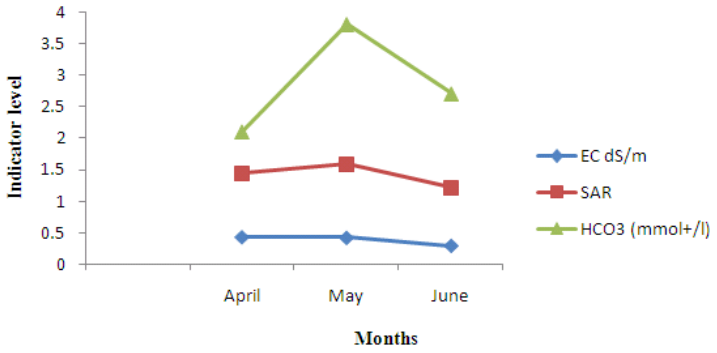

Fig. 4.1: Concentration of salts in irrigation water at canal 15 during growing season.

Water quality:

Figure 4.2 gives the salinity and sodicity levels during the growing season (April, May and June) for canal 15. The result indicated that EC of the water ranged from 0.28 to 0.42 dS/m for the whole growing season, the highest values were found in April and May whereas the lowest value was found in June. The results showed

that the SAR values were ranged from 1.21 to 1.44 during the growing season, the high value was found in May and the lowest value was found in June. The quality of the water for irrigation was appraised according to classification system based upon EC and SAR of U.S.A Salinity Laboratory Classification (American Society of Civil Engineers, ASCE. 1990 and Ayers, R. S. and Westcot, D. W. 1985). The irrigation water for the whole growing season was within class C_2 (EC more than 0.25dS/m) except in June when it was of low salinity level where EC level was less than 0.25dS/m. All growing season had low SAR values which is within the usual range of irrigation water and classified as S_1. The classification of the irrigated water according to the U.S.A Salinity Laboratory Classification is C_2-S_1. This is due to the fact that the Blue Nile is at its lowest level during April, May and June (Mustafa 1973). The rise in the salinity of water measured at farm gate may be attributed to salinity of the soil. Also the prevalence of high temperature at April and May increased the evapotranspiration which might resulted in net increase in salt concentration.

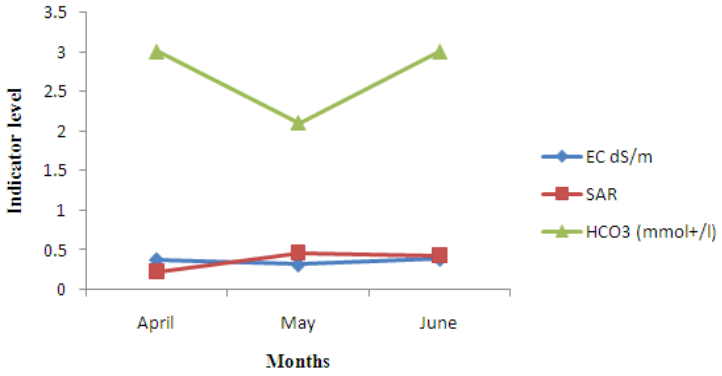

Fig. 4.2: Concentration of salts in irrigation water at canal 17 during growing season.

Table 4.1: Soil Chemical properties.

Depth cm	EC_e dS/m	SAR	ESP	$CaCO_3$	HCO_3	pH
0 – 5	0.6	4.2	6.8	3.13	8.50	8.02
5 – 20	1.9	11.8	19.1	3.13	8.50	7.99
20 – 42	5	30.3	49.0	4.60	7.50	8.24
42 – 65	18	47.1	76.1	4.25	8.50	7.54
65 – 90	22	60.8	98.2	4.40	9.00	7.33
90 – 130	16	33.1	53.5	3.33	1.00	7.37

Table 4.2: Soil Physical properties.

Depth cm	B.D g/cm^3	Clay %	Silt %	Sand %	Texture
0 – 5	1.71	34.20	10.40	55.40	SCL
5 – 20	1.75	34.50	09.90	55.60	SCL
20 – 42	1.75	52.20	10.20	37.60	C
42 – 65	1.79	45.10	12.10	42.80	C
65 – 90	1.82	42.20	10.50	47.30	SC
90 – 130	1.82	47.40	11.10	41.50	C

4.1 Impact of the management practices on reducing salinity and sodicity problems for fodder crop production:

Fresh yield:

Figure 4.3 shows the effect of different treatments on Abu Sabien fresh yield. The data ranged from 12.5 to 46.0 ton/ha. Statistical analysis indicated highly significant effect (0.01) of the imposed interventions (irrigation intervals, tillage operation and organic amendments) on Abu Sabien fresh yield. For tillage operation treatments (Chisel-harrow, plow-harrow and harrow only) the only significant difference on Abu Sabien fresh yield (highly significant difference 0.01) was found between chisel-harrow operation and plow-harrow operation. But between chisel-harrow and harrow only, and between plow-harrow and harrow only there was no significant difference. However, the differences were found highly significant (0.01) between irrigation intervals and organic amendment

As given also in figure 4.3 the effect of organic amendments, tillage operation and irrigation intervals on Abu Sabien fresh yield showed no significant difference, and the results are in the following order, FYM T_3I_7, CHM T_3I_7, FYM T_1I_7, CHM T_1I_7, FYM T_2I_7, CHM T_2I_7, CHM T_3I_{14}, CHM T_2I_{14}, CHM T_1I_{14}, CHM T_3I_{21}, CHM T_1I_{21}, CHM T_2I_{21}, FYM T_3I_{14}, FYM T_1I_{14}, FYM T_2I_{14}, FYM T_3I_{21}, FYM T_1I_{21} and FYM T_2I_{21} It is evident that

treatment of FYM T_3I_7 had increased the fresh yield by 268% than the treatment of FYM T_2I_{21} and by 183.07% than treatment FYM T_3I_{21}.

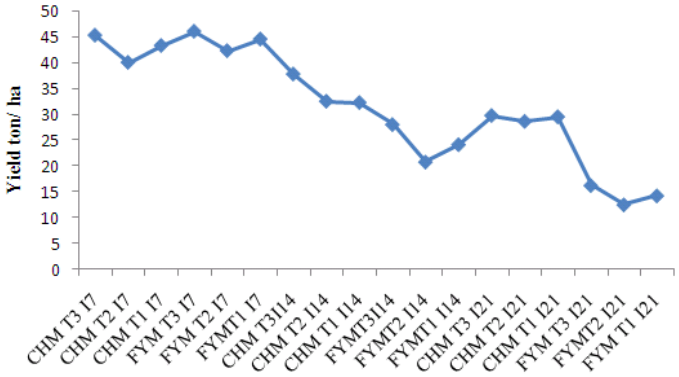

Fig. 4.3: Effect of manure, tillage operation and irrigation intervals on Abu Sabien fresh yield.

Generally fresh yield increased with decrease in irrigation intervals. This is in agreement with (Ahmed, 1995). The effect of the irrigation intervals was enhanced by the addition of organic amendments and application of chisel harrow operation. It seems that more frequent irrigation promoted microbial decomposition of the organic amendments and consequently increased the release of more nutrients. The increase in yield due to more frequently irrigation may be attributed to alleviation of salinity and the consequent increase in plant height. The addition of manure promoted aggregation and supplied nutrients to the crops and hence, increased crop yield.

Fresh yield increased with applications of chisel-harrow due to the reduction of penetration resistance and bulk density and to increase in air permeability. This finding is agreement with (Daniel et al, 2005), who found that the applications of chisel reduced penetration resistance and bulk density hence increased fresh yield.

Plant height:

Figure 4.4 depicted the effect of different treatments on Abu Sabien plant height. The data ranged from 84.33 to 160.7 cm. Statistical analysis indicated that Abu Sabien plant height was highly significantly affected by irrigation intervals, tillage operation and organic amendments. Plant height increased with decrease in irrigation interval and application of tillage operation. At 7days intervals harrow only and chisel-harrow operation significantly increased plant height, and at 14 days interval only chisel-harrow operation had a significantly increased plant height. Figure 4.4 also shows that the interaction of organic amendments, tillage operation and irrigation intervals on Abu Sabien plant height had no significant difference, and the result is in the following order, CHM T_3I_7, CHM T_1I_7, CHM T_3I_{14}, FYM T_1I_7, CHM T_2I_7, FYM T_3I_{14}, CHM T_1I_{14}, CHM T_3I_{21}, CHM T_1I_{21}, FYM T_1I_{21}, FYM T_3I_{21} and FYM T_2I_{21}.

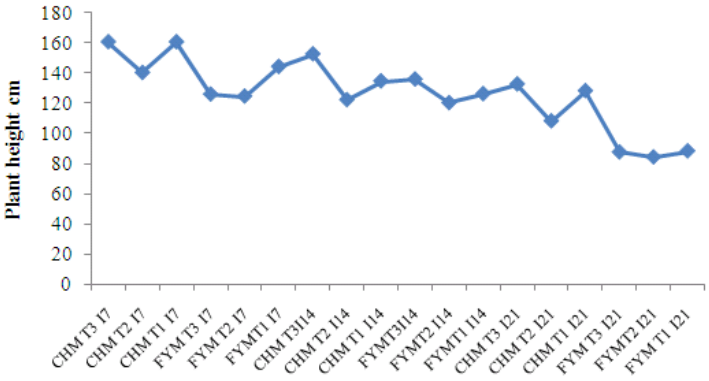

Fig. 4.4: Effect of manure, tillage operation and irrigation intervals on Abu Sabien plant height.

As indicated above, the plant height increased with decrease in irrigation interval. This is in agreement with Elbashir (1994), and Ahmed (1995). This may be due to the fact that frequent irrigation reduced both osmotic

and water stresses and increased soil water potential (Hillel 1982). Also it increased water uptake by plant roots which enhanced cell elongation, nutrients uptake and subsequently lead to extensive plant growth. Plant height increased with applications of chisel-harrow. This result agreed with the finding of Mahmoud (1985). Chisel plough break through deep hard layer. This enhances deeper penetration of root system and the final result is relatively tall plant.

Root length:

Table 4.5 and figure 4.5 depicted the effect of different treatments on Abu Sabien root length. The data ranged from 0.147 to 0.34 m Statistical analysis indicated that the increase in Abu Sabien root length was highly significant as affected by irrigation intervals and tillage operation. In general, root length increased with decrease in irrigation interval, and application of chisel-harrow. At 7days intervals chisel-harrow operation significantly increased the root length. The effect of organic amendments, tillage operation and irrigation intervals on Abu Sabien Root length had no significant difference, and the result is in the following order, FYM T_3I_7, FYM T_3I_{14}, CHM T_3I_7, FYM T_1I_{14}, CHM T_3I_{14}, CHM T_2I_7, FYM T_1I_7, CHM T_1I_{21}, CHM T_1I_7, CHM T_1I_{14}, FYM T_1I_{21}, CHM T_3I_{21}, CH T_2I_{14}, CHM T_2I_{21}, FYM T_2I_{21}, FYM T_2I_7, FYM T_3I_{21} and FYM T_2I_{14}.

Figure 4.5 also illustrates trends of root length of FYM treatments in a 60 cm soil depth. Root length was deeper in the soil in the application FYM T_3I_7 whereas the application of FYM T_2I_{14} was the lowest one. As depicted above root length increased with decrease in irrigation interval, and application of chisel-harrow. The reduction of irrigation intervals increased the amounts of available water to plant. This may due to an increase of both size and roots weight and consequently root length. As given by Daniel et al, (2005) the increase in root length with application of chisel-harrow may be due to the reduction of penetration resistance, bulk density and increasing air permeability by chisel-harrow.

Table 4.4: Effect of different treatments on Abu Sabien root length.

	CHM			FYM		
	I_7	I_{14}	I_{21}	I_7	I_{14}	I_{21}
Chisel-harrow	29.67	23.67	18.00	34.00	29.67	16.00
Plow-harrow	22.33	18.00	17.00	17.00	14.67	17.00
Harrow	19.67	22.33	22.33	22.67	24.00	18.33
LSD0.01 (I)= 4.52	I means Irrigation intervals					
LSD0.01 (T)= 5.711	T means Tillage operations					
LSD0.01 (IT) = 5.788	IT means Tillage operations and irrigation intervals					

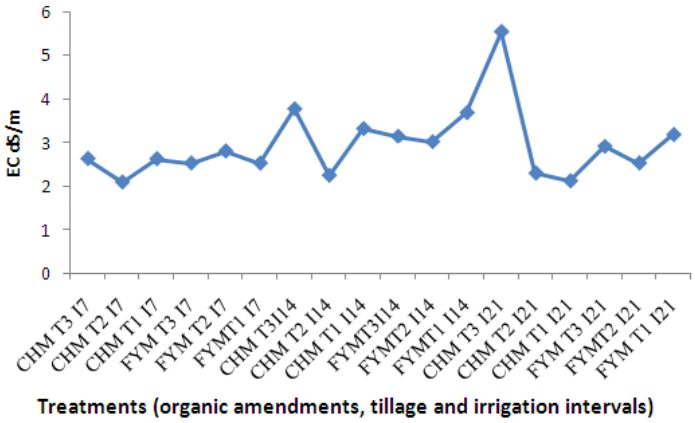

Fig. 4.5: Effect of manure, tillage operation and irrigation intervals on soil EC (depth 0.3 m).

Salt redistribution (EC_e):

Table (4.5) shows the effect of different treatments on EC_e at soil depths 0 to 0.30 and 0.30 to 0.60 m respectively at the end of the experiment. Statistical analysis indicated that there was no significant difference between all treatments and irrigating Abu Sabien with or without tillage. Organic amendments reduced EC_e values below the initial level in all treatments.

Figure 4.6 depicted the main effect of treatments on salinity of 0 to 0.30 m depth. The initial EC_e was reduced by 44% when irrigated every 7days compared to other intervals. The tillage operations lowered the EC_e values by 6, 20 and 31% when land is prepared using chisel-harrow, harrow only and plow-harrow, respectively.

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The interaction of all treatments on EC_e of the soil depths 0 to 0.30 m had no significant effect, and lowered the EC_e below the initial except the application of CHM T_3I_{21} desalinized it by 51%. Figure 4.7 shows the initial EC_e values for 0.30 to 0.60 m soil depth. The initial EC_e values were reduced by 71.49, 61.38 and 49.8% when irrigated every 7, 14 and 21 days respectively. Whereas, tillage operation lowered the EC_e by 70.24, 46.55 and 65.88% when, tillage operation practiced by chisel-harrow, plow-harrow and harrow treatments.

Table 4.5: Effect of different treatments on EC_e redistribution.

Soil depth (m)	Initial EC dS/m	Tillage operation	CHM			FYM		
			I_7	I_{14}	I_{21}	I_7	I_{14}	I_{21}
00 – 0.30	3.65	Chisel	2.630	3.783	5.540	2.530	3.150	2.913
		Plow	2.093	2.247	2.297	2.803	3.023	2.530
		Harrow	2.627	3.330	2.120	2.527	3.697	3.190
0.30 -0.60	12.8	Chisel	3.260	3.680	2.787	5.087	5.147	2.893
		Plow	3.277	4.240	2.847	4.607	5.387	5.847
		Harrow	2.817	10.88	3.967	2.847	9.217	11.32

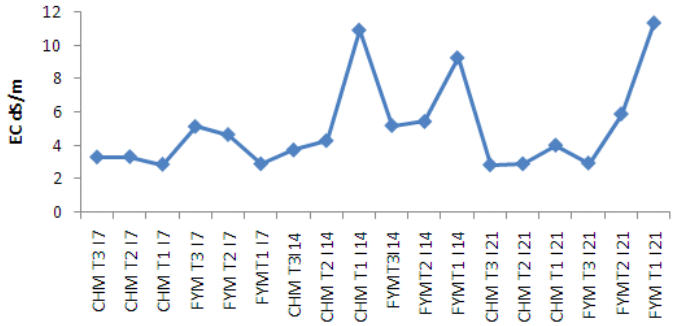

Fig. 4.6: Effect of manure, tillage operation and irrigation intervals on soil EC (depth 0.60 m).

Sodium adsorption ratio redistribution (SAR):

Table (4.6) shows the data of the soil SAR redistribution at the end of the season. The data ranged from 4.61 to 41.84. Statistical analysis indicated that the effects of treatments were not significant.

Figures 4.8, and 4.9 show that the initial SAR of the 0 to 0.30 m depth were reduced by 52.35, 34.79 and 33.77% when irrigated every 7, 14 and 21 day respectively. At all irrigation intervals, chicken manure and farm yard manure decreased the SAR value below their initial one. The response of SAR to irrigation intervals was found to be polynomial relation and may be represented by the following regression equation:

$Y = - 1.381\ II^2 + 9.576\ II.$ …….. (Equation 4.1)

($R^2 = 0.96$).

Where: Y = SAR and II = Irrigation interval.

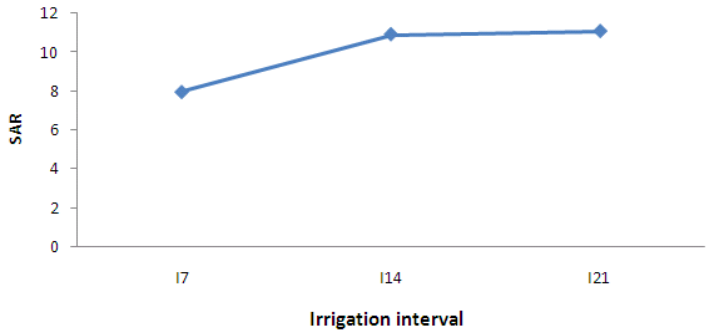

Fig. 4.7: Effect of irrigation intervals (7, 14 and 21 days) on soil SAR (depth 30 cm).

Figure 4.8 depict the graphical representation of the previous relation. It's evident that SAR value decreased with decreased in irrigation intervals. In general, irrigation with or without amendments decreased the SAR values.

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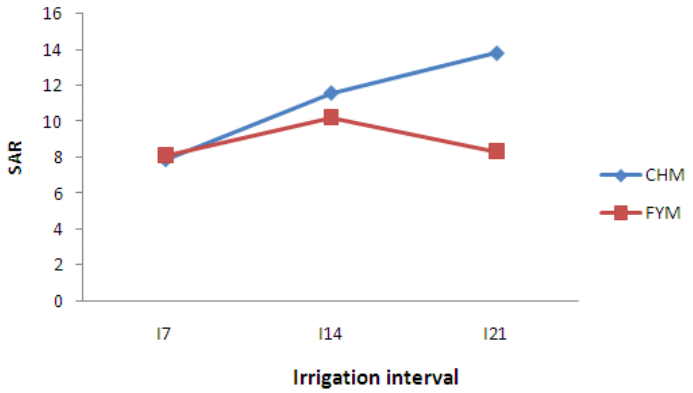

Fig. 4.8: Effect of manure and irrigation intervals on soil SAR (depth 0.30 m).

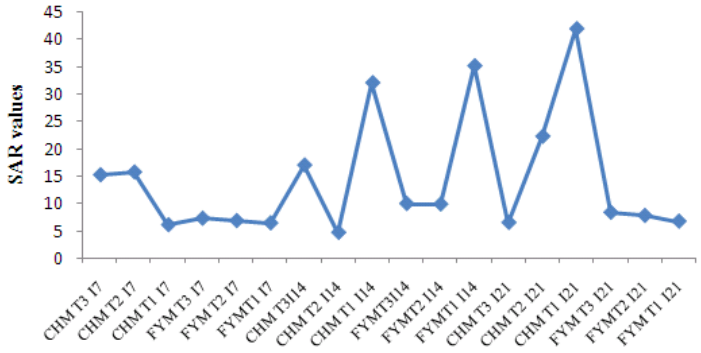

Fig. 4.9: Effect manure, tillage operations and irrigation intervals on soil SAR (depth 0.60 m).

Also the effect of irrigation intervals and organic amendments (CHM and FYM) on SAR values could be expressed by a polynomial relation as shown in the following regression equations:

(1) $Y = -0.750X^2 + 8.875X$…… (Equation 4.2)
($R^2 = 0.98$)
Where: Y = SAR and X = chicken manure (CHM).

(2) $Y = -2.001X^2 + 10.26X$…… …. (Equation 4.3)
($R^2 = 0.93$)
Where: Y = SAR and X= farm yard manure (FYM).

Figure 4.9 depict the graphical representation of the previous relations.

Figure 4.10 shows that the initial SAR value of 0.30 to 0.60 m depth was reduced by 76.41, 55.30 and 61.66% when irrigated every 7, 14 and 21 days respectively. The tillage operations reduced SAR value by 73.63, 47.20 and 72.46% when using chisel-harrow, plow-harrow and harrow treatments respectively.

Table 4.6: Effect of different treatments on SAR redistribution.

Soil depth (m)	Initial SAR	Tillage operation	CHM			FYM		
			I7	I14	I21	I7	I14	I21
00 – 0.30	16.7	Chisel	8.743	14.29	25.65	8.430	11.58	8.907
		Plow	5.183	8.450	7.430	8.557	9.393	8.823
		Harrow	9.620	12.00	8.357	7.207	9.613	7.213
0.30 – 0.60	40.38	Chisel	15.15	16.94	6.433	7.205	9.900	8.290
		Plow	15.66	4.610	22.19	6.770	9.800	7.700
		Harrow	6.010	31.98	41.84	6.360	35.07	6.667

* The effect of treatments at each depth was not significant different at the 0.05 level probability.

Exchangeable sodium percentage redistribution (ESP):

Table (4.7) shows the data of the soil ESP values redistribution at the end of the season. The data ranged from 9.713 to 67.62. Statistical analysis indicated that the effects of all treatments were not significant. The initial soil ESP value of the 0 to 30 cm depth was reduced by 52.39, 34.83 and 33.80% when irrigated every 7, 14 and 21 days respectively. The applications of irrigation interval with organic amendments were reduced soil ESP values by 53.05, 51.76, 50.24, 38.99, 30.66 and 17.36 when CHM I_7, FYM I_7, FYM I_{21}, FYM I_{14}, CHM I_{14}

and CHM I_{21} were applied respectively. In general, all treatments were decreased the ESP values except the application of CHM T_3I_{21} which increased the ESP values by 53.46% over the initial ESP value.

The initial ESP value of 30 to 60 cm depth was lowered by 72.64 when irrigated every 7days compared to the intervals. In general, all treatments have decreased the ESP values except the application of CHM T_1I_{21} and the application of FYM T_1I_{14} which increased the ESP values by 20.19 and 0.75% respectively. Desalinization of the top 60 cm soil depth was observed in all treatments of irrigation and tillage operation. Irrigation with different levels of interval was found to be more efficient in salt leaching over other treatments (Ahmed 1995). Chisel-harrow practice reduced the penetration resistance, bulk density and increasing air permeability (Daniel et al, 2005). This may increase leaching efficiently and consequently salt leaching. Also, chisel-harrow practice did not turn over the soil which may had a positive effect on soil desalinization and consequently efficient use of water.

Table 4.7: Effect of different treatments on soil ESP redistribution.

Soil depth (m)	Initial ESP	Tillage operation	CHM			FYM		
			I_7	I_{14}	I_{21}	I_7	I_{14}	I_{21}
00 – 0.30	27.01	Chisel	14.13	23.10	41.45	13.62	18.71	14.39
		Plow	8.373	13.68	12.01	13.83	15.18	14.26
		Harrow	15.55	19.40	13.51	11.65	15.54	11.66
0.30 – 0.60	56.26	Chisel	24.47	27.38	10.39	11.64	16.00	13.40
		Plow	10.94	15.83	12.44	25.30	25.95	35.85
		Harrow	9.713	51.67	67.62	10.28	56.68	10.76

* the effect of treatments at each depth were not significant different at the 0.05 level of probability

Soil reaction (pH):

Table (4.8) showed the data of the soil pH redistribution at the end of the season. The data ranged from 7.933 to 9.067. Statistical analysis indicated that the effects of treatments were not significant. The main effects show that the initial pH of the 0 to 30 cm depth was increased by about 4.30, 5.00 and 6.29% when irrigated every 14, 7 and 21 day respectively. At all irrigation intervals chicken manure and farm yard manure increased the pH value over their initial ones. In general, all treatments were increased the pH values except the application of CHM T_1I_{14} was reduced the pH values by about 2% below the initial pH. The initial pH value of 30 to 60 cm depth was increased by 7.90, 8.61and 9.96% when irrigated every 14, 7 and 21 days respectively. In general all treatments were increased the pH values.

The increase in soil pH this is due to the leaching of soluble salts from saline-sodic soils. This in agreed with (Brady et al, 2002). Virtually, all soils treatments have an alkaline reaction (pH greater than 7.9). This is due to the high ESP which has a tendency to increase the pH beside the concentrations of bicarbonate.

Table 4.8: Effect of different treatments on soil pH redistribution.

Soil depth (m)	Initial pH	Tillage operation	CHM			FYM		
			I_7	I_{14}	I_{21}	I_7	I_{14}	I_{21}
00 – 0.30	8.09	Chisel	8.433	8.733	8.067	8.767	8.200	8.767
		Plow	8.267	8.633	8.527	8.933	8.560	9.067
		Harrow	8.400	7.933	8.467	8.167	8.567	8.700
0.30 – 0.60	7.82	Chisel	8.067	8.567	8.667	8.833	8.467	8.767
		Plow	8.567	8.300	8.100	8.867	8.633	8.700
		Harrow	8.633	7.967	8.200	8.800	8.533	8.843

* The effect of treatments at each depth were not significant different at the 0.05 level probability.

Conclusion and Recommendations:

Conclusions:

Soil salinity and/ or sodicity significantly limit crop production and the consequences are damaging in both socioeconomic and environmental terms. Reclamation of salt-affected soils require an integrated management approach, including consideration of socioeconomic aspects, mapping, monitoring and maintenance of irrigation schemes and reuse and/or safe disposal of drainage water. Implementation of efficient irrigation, drainage tillage operation and good farming practices can prevent and, in some cases, reverse salinization and sodification. If appropriate management practices are not applied in time the land may be degraded and crop production deteriorated. The experiment concluded that:

- Irrigation every 7 days with application of chisel-harrow and addition of farm yard manure (FYM T_3I_7) gave the highest fresh yield and root length.
- Irrigation every 7 days with application of chisel-harrow and addition of chicken manure (CHM T_3I_7) increased plant height.

Recommendations:

To achieve the study stated objectives it is recommended to implement the following recommendation:-

- Irrigating every 7 days with application of organic amendments (FYM and CHM) it is very better to give high fresh yield of Abu Sabien in both saline-sodic and non saline non sodic soils.
- Application of chisel-harrow and harrow only increased fresh yield of Abu Sabien in both saline-sodic and non saline non sodic soils
- Conduct the same study in other soils affected by salinity and/ or sodicity in other parts of the country.
- Other economical crops (e.g. wheat, cotton, vegetables …etc) should be tried in such research.
- It is recommended to determine the degree of fermentation needed for adding manure.

Rererences

Abdel Rahim, H.A., 1985. The effects of irrigation regimes and some soil amendments on salt redistribution and forage Sorghum (*Sorghum bicolor* L.) grown on a saline-sodic clay soil. M.Sc. Thesis, University of Khartoum.

Adam, A.I., B. Suleiman, M. El-Badawi and A. Doka, 1975. Semi-detailed soil survey and land capability classification of North East Khartoum area. Bulletin No. 54. Soil survey Administration. Wad-Medani, Sudan.

Ahmed, A.B., 1995. Impact of soil water management on salt leaching and forage sorghum growth in a Shambat soil. M.Sc. Thesis, University of Khartoum.

American Society of Civil Engineers (ASCE), 1990. Agricultural Salinity Assessment and Management. Editor. Tanji, KK, ASCE Manuals and Reports on Engineering Practice No. 71, ASCE, New York, USA.

Ayers, R.S. and D.W. Westcot, 1985. Water quality for agriculture. Irrigation and drainage paper 29, FAO, Rev., 1: 174.

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

Daniel, S.W., M.B. Kirkham and J.B. Sisson, 2005. Crop and Soil Response to Wheel-Track Compaction of a Clay pan Soil. In Agron. J. 98: 637-643. (http://agron.scijournals.org/cgi/content/full/98/3/637).

Doka, El-Abbas, 2002. Soil and water characterization for crop production. College of water sciences and technology Wad Al-Magbool (Khartoum North). Sudan University of science and technology, College for agricultural study. Bulletin No. 4.

El Amin, A.E., 1980. Effects of water-nitrogen-gypsum interaction on Abu Sabien (Sorghum bicolor L.) production grown in a saline-alkali soil. M. Sc. Thesis, University of Khartoum.

Elbashir, 1994. The effect of irrigation frequencies and organic amendments on soil properties and forage Sorghum (bicolor (L.) Moench) production in a salt-affected soil. M.Sc. Thesis University of Khartoum.

Gabir, A.M., 1984. The effect of irrigation frequencies and some soil amendments on Lucerne (Medicago sativa L.) Grown in a saline-sodic clay soil south of Khartoum area. M.Sc. thesis, University of Khartoum.

Karouri, M.O.H., K. Al Fadil and A. Gabir, 1980. Effect of gypsum, farm yard manure and green manure on the reclamation of Sodic Soils in south of Khartoum area. Agric. Res. Council, Sudan.

Mahgoub, M.O., 1979. Reclamation of Saline-sodic soils in Khartoum province. M.Sc. Thesis University of Khartoum.

Mahmoud, H.A., 1985. Evaluation of various tillage practices for soybean under mechanized rain fed conditions. M.Sc. Thesis University of Khartoum.

Mustafa, M.A., 1973. Appraisal of water quality of the Blue and White Niles for irrigation use. African Soils, 18(2): 113.

Mustafa, M.A., 2007. Desertification processes. Published by: UNESCO Chair of Desertification, University of Khartoum, 7: 129-170.

Mustafa, M.A. and E.A. Abdel-Magid, 1982. Interrelation of irrigation frequency, urea, nitrogen and gypsum on forage sorghum growth on a saline sodic clay soil. Agron. J., 47: 447.

Nachtergaele, F.O., 1976. Studies on saline and sodic soils in Sudan. Tech. Bulletin No. 24. Soil Survey Administration., wad Medani, Sudan.