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The Effect of Irrigation Frequency and Farm Yard Manure on Salt Leaching Under Saline – Sodic Soil

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***Abstract**: Northern state, Sudan is extremely affected by desertification and Salinization processes, there for this study aimed to investigate an effective method to improve the salt affected soil. Two field experiments were carried out in two successive seasons (July 2005 – June 2006) at Dongola University farm, in the North State to investigate the effect of irrigation frequency (7 and 14 days) and farm yard manure (M0 , M1 , M2 , andM3) on salt leaching undersaline – sodic soil . The experiment was designed in spilt – plot design , where irrigation frequency was assigned in the main plots (6x28m) and farm yard manure were the sub – plots (6x7m) .The total cultivated area was 1342m2 for each experiment. The quantity of water applied was estimated according to Jensen andHaise (1963) . The total water quantity was the same by the end of the season. In general , the result indicated that irrigation frequency of 7 days enhanced salt leaching from the root zone. Generally , the reduction in electrical conductivity (ECe) and sodium adsorption ratio (SAR) due to irrigation frequency was more effective in 7 day irrigation interval as compared with 14 – day irrigation interval . the data obtained indicated that the addition of FYM 10 ton/feddan, significantly degreased the (ECe) and the (SAR) and leached them below the root zone. So, we can conclude that the efficiency of salt leaching is markedly affected by irrigation frequency and yard manure.*

1. Introduction

Sudan is a large country (2.5 X 106 km2) dominated by arid and semi arid tropical region that favour the formation of salt affected soil. (Mustafa 1986), in Sudan reports of soil survey administration 1976 indicates that more than 250 thousand hectares of land in the Northern Sudan are affected to some degree by salinity and sodicity. According to these reports, the largest areas found to the north of Khartoum on both banks of the main Nile, south of Khartoum to the northern plant of Gezira and along the White Nile.

The survey curried out by the Land and Water Research Center of the ministry of Agriculture, proved that about 11% of the 64,000 hectares surveyed in White Nile, Gezira, Khartoum and Northern State are affected to some degree by salinity and or sodicity.

Dongola area is severely affected by desertification and salinization processes . Further more , the land is much fractionated due to land tenure laws . The fertile and productive first terrace soils are intensively used . This prompted horizontal expansion of agriculture into the upper terrace of salt affected soil (IzzEldin , et al . 2000). The soils of the north state are in general alkaline in reaction having pH values ranging between 7.2 – 8.5 , (Gerif and Gureir) are the most fertile soile where as high terrace least fertile (Ibrahim 1990) . Soil salinity will usually be greater than the salinity of irrigation from the water used because will remain in the soil (Baly lock 1994) .

Most of the salt – affected soils of sudan have relatively high clay content , high ECe , low organic matter and nitrogen , high base saturation status . The profile generally contains appreciable amount of CaCO3 and gypsum crystals (Nachteragele , 1976) . The potassium content is considered adequate, whereas sodium bicarbonate, extractable phosphorus is considered low for most agriculturally important crops . These clay soils have high phosphorus retention that increases with salinity and decreases with sodicity (Mustafa , 1986) .

Rhoades (1977) , showed that the most amount of ca++ and Mg++ replaced and Na adsorbed increase as the concentration of Na in solution is increased . The cation in the soil solution are in equilibrium with the cations or counter balancing the negative charge on the clay . This equilibrium is governed by the Empirical Gapon Equation which states that the ratio of the sodium ions (Na+) balancing the charge of the clay surface and the divalent ions Ca++/ Mg++ on the clay surface proportional to the ratio of the square rooy of the total divalent concentration . The right hand side of the equation is referred to as the sodium adsorption ratio (SAR) (Qurik , 1994).

The exchangeable sodium percentage (ESP) is the amount of adsorbed sodium on the soil exchange complex expressed as a percent of the total cation exchange capacity in milliequivalents per 100g of soil (Richards , 1954; FAO ,1970). Soil crust presents presents a serious barrier for emergence of seedling , (Richards , 1954 ; Black , 1957).

The exchangeable sodium percentage (ESP) is probably the most widely used measure for characterizing the soil (Bower and Hachter , 1962 ; Sposito , 1989) . In general , ESP values represent true field condition concerning sodium status (Nadler and Magaritz ,1981).

Barrow , (1979) ,found that phosphate in solution , increased with the increase in temperature . This effect was interpreted as in effect of temperature on the position of equilibrium between soluble phosphate and adsorbed phosphate .

Allison (1964) , reviewed the principles and procedures of the reclamation of saline and sodic soils and proposed the following step :

1)Leaching to remove soluble salts : leaching of salt – affected soils in new project area , and futher of previously irrigated but abandoned land in older project is an essential part of the overall program of irrigated agriculture .

2) Leaching to remove Boron : excluding boron elements from the soil is very important because profound effect of this element on plant growth , where as , boron salt is found in toxic concentration in many arid soils of the world .

3) Reclamation procedures : there are various system of reclaiming saline and sodic soils including , flushing basin method , furrow basin method , trenching and use of high salt waters . Improving saline soils is easier than sodic soils which is difficult and may be impossible to reclaim , due to the decreased permeability of the soil , where are reclamation of salinity depends upon some procedures (deep ploughing and leaching)

Reclamation of saline soils is leaching and removal of excessive salt replacement of exchangeable Na by Ca (Izzeldihn , 2000) .

In Sudan (Green and Snow , 1939) pioneered the reclamation work in irrigated Gezira vertisols . Their result showed that Gypsum improved water permeability and considerably increased cotton yield in the first year .

The use of subsurface tile drainage system was unsuccessful .

The success of reclamation depends on the selection of the appropriate method which suits the prevalent climatic , soil , crop , water and geological condition (Izzeldin , 1996) .

The failure to recognize that saline and sodic require special management practice may result in low production or in complete crop failure . The special practices can be followed over a period of time to improve lands and to prevent reclaimed land from again becoming unproductive (Richards , 1954) .

Hydrotechnical method include : irrigation , leaching and drainage.

Maintaining favorable salt balance in the soil requires proper and efficient irrigation methods . Water application should be sufficient to maintain favorable salt balance in the soil , but without excessive leaching of the plant nutrients and without materially to the doubling to the drainage problems (Israelsen and Hasen , 1962)

Meek et al . (1979) , reported that the rapid fixation of phosphorus in calcareous soil can be reduced by applying organic matter . The results showed that organic amendments reduced ECe , evaporation and increased soil water conservation . Also the manure application increased $Na2Co3$.

Warren and Johnston , (1960) suggested that FYM plowed into a cultivated soil layer is distributed through the whole soil and it is more effective than chemical fertilizer broadcasted by hand to the soil surface . The effectiveness of agypsum as a soil amendment increased by the application of manure , nitrogen and phosphorus fertilized (Russell, (1950)).

Cabier , (1984), reported the advantage of the 14 day irrigation interval to the 7 day irrigation frequency with respect to salt leaching of the vertisoles . This was explained as follows ; irrigation every 14 days permitted the top soil to dry up considerably to form cracks facilitating better salt leaching . While the 7 day interval kept the top soil always wet and the high ESP may cause sealing of soil surface and consequently the low permeability .

2. Materials and method

Dongola area consists of a basement of Precambrian metamorphic rocks overlain by the Nubian sandstone , which is known for its abundant ground water (Izzeldin,1983) observed out crops of basement complex just north kerma town . Alluvial deposits dominate the flood plains along the Nile bank . 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 (Anderw , 1947) .

The geomorphology of the area is characterized by sand dunes and wind hammocks . The soils of the study area is divided into two main groups , namely , soils of the recent flood plain and soils of the high terrace (Karouri , 1978).

A profile was dug in the experimental site and described according to the standard soil survey procedure (Soil Taxonomy , 1996). The physical and chemical properties of this profile are reported in Table (1).

Table-(1):-

Depth Cm	**Ph paste**	**Ece**	Soluble cations(meg/l)				Soluble a nions(meg/l)				SAR	S.P	CE C	Particle size class				**CaCo**
			Na	Ca	Mg++	K++	Co_3	Hco_3-	Cl-	So—4					**clay**	**silt**		
0-15	**7.6**	19.3	176.	11.8	2	0.009	0.0	11.5	**55.5**	112.6	67.8	42.	27.	53.3	22.2	24.5	25.9	5.4
15-35	**8.9**	31.6	278.	26.7	7.9	0.001	0.0	13.9	**178.3**	123.8	66.3	53.	55.	49.9	30.9	19.2	31.5	4.8
35-55	**7.3**	23.9	197.	18.2	6.3	0.017	0.0	10.2	**88.5**	140.3	40.1	49.	57.	58.7	24.5	16.3	42.9	6.4
55-75	**7.4**	27.2	236.	22.5	5.8	0.008	0.0	12.9	**122.6**	136.5	62.3	46.	57.	42	27.3	30.5	40.4	6.2
75-95	**7.6**	13.6	119.	9.3	3.5	0.000	0.0	8.5	**71.5**	56.2	48.0	35.	36.	69.8	17.8	12.4	32.5	6.0
95-12	**7.3**	22.3	211.	9.7	1.5	0.001	0.0	11.7	**80.6**	130.7	84.6	38.	23.	62.8	19.5	17.7	26.5	4.3
120+	**7.5**	11.8	105.	9.6	3	0.001	0.0	9.6	**63,2**	45.2	49.2	32.	5.2	89.5	2.3	8.2	17.8	3.1

3. PROFILE DESCRIPTION:

0-15 CM : Brown (10YR6/3) dry , dark brown(10YR3/3) moist , fine granular to blocky , sandy loam ; slightly sticky , slightly plastic, slightly CALCAREOUS MATRIX ,FEW CACO3 WHITE CONCRETION , CLEAR smooth boundary , PH 7.6 .
15-35 CM : light yellowish to brown (slightly sticky , plastic 10YR 6/4) dry , dark brown (10 YR 4/3) most, loam , weak platy structure, hard dry , firm moist , few tubular pores , many CaCO3modules , very strong calcareous matrix , smooth boundary , PH 8.9 .
35.55 CM : Gray to brown (10YR 5/2) moist and dry , sandy loam weak granular , medium sticky and plastic , few fine pores , sand grains , gray CACO3 nodules , smooth boundary , PH 7.3
55.75CM : very pale brown (10 YR 7/3) dry , dark grayish to brown (10 YR 4/2) moist , loam, weak medium and fine sub angular , blocky , slightly sticky , slightly plastic , firm moist , hard dry , many CACO3 nodules and concretions , gradual smooth boundary ,PH 7.4 .
75 -95CM : Light brownish to gray (10 YR 6/2) dry , dark Brown (10 YR 4/3) moist , weak , platy structure , slightly sticky and plastic , sandy loam , friable moist, hard dry , few CACO3 white concretion , PH 7.6 .
95-120 CM: brown (10 YR 6/3) moist and dry , sand clay loam , moderate granular , hare , non-sticky and plastic , soft dry , non-calcareous matrix , abrupt to smooth boundary , PH 7.3 .
120+ CM : dark grayish to brown (10 YR 4/2) most and dry , sandy , very hard , granular , non-sticky and non-plastic , loose moist , loose dry , non-calcareous matrix , PH 7.5 .

Experiment:

The experiment was conducted at the university of Dongola farm during two consecutive seasons (2004/05 and 2005 /06) , at the eastern bank of the Nile . The effect of irrigation frequency (F) and farm yard manure (M) on salt leaching under saline – sodic soil

The treatments were two irrigation frequencies 7 and 14 days , and four levels of farm yard manure , zero (M0) , 5 tons/feddan (M1) , 10 tons/feddan (M2) and 15 tons/feddan (M3) tons/feddan . The experimental design used was split plot design , where irrigation interval was assigned as the main plot (6 x 28m2) each of which was divided into four subplots (7 x 6m2) to accommodate the four levels of farm yard manure .

Application of farm yard manure was applied to the plots at the four predetermined rates mentioned earlier.

A predetermined quantity of irrigation water (Qi) was delivered to the sub-plots using parshal flume in both seasons. This quantity was estimated by the following relationship:

$$Qi\ mm = \frac{Kc.ETp\ X\ F\ X100}{Ei}$$

Where:
Kc = Crop coefficient.
ETp = Potential evapotranspiration (mm/day).
F = Irrigation frequency days.
Ei = Irrigation application efficiency assumed (as 70%)

Soil samples (2kg) were collected at 3 soil depths (0 – 30, 30 – 60 and 60 - 90 cm) in each sub-plot before sowing and at harvest for both seasons. A total of 288 soil samples were collected for analysis. The samples were air dried, grinded, passed through a 2.0mm sieve and kept in labeled plastic bags. Three replicates of clods were taken at an increment of 0.2m from the surface to one meter depth, for measuring the soil bulk density at different depths.

Soil analysis The particle size distribution was determined by pipette method and bulk density by the cold method (Black, 1962). The chemical properties of the soil including electrical conductivity of the saturated extract (ECe), Cation exchange capacity CEC, soluble Ca^{++}, Mg^{++} and Na^{+}, exchangeable sodium Na^{+} $CaCo_3$ and pH, where determined according to the standard procedure of the U.S Salinity Laboratory Staff (Richards, 1954).Exchangeable sodium percentage Esp = 100 (Na x CEC) and sodium adsorption ratio SAR = $Na / \frac{\sqrt{Ca+mg}}{2}$ were then calculated.

.Soil amendments The following four levels of farm yard manure were used in the research work 0, 5, 10 and 15 ton/feddan.

Irrigation water system Parshal Flume 5cm width, was used for delivering a specific quantity of water to the plots. The sources of water was the River Nile, which is of good quality (Mustafa 1973)

Estimated Irrigation water Requirements for Abu-sabien (*Sorghum bicolor* L. Moench) in Dongola area for two seasons.

Irrigation Data for Abu sabien (*Sorghum bicolor* L. Moench) grown during the First season (July – September 2006)

4. RESULTS & DISCUSSIONS:

Treatments effect on initial ECe (dS/m) on the (0-30cm)soil depth at the first and season was shown in Fig(1-a,b)The data showed that the farm yard manure reduced ECe by 85%.

78%,75.3%and 71.8% for FYM at M2, M1,M3, and Ma in the first season .and by 84%,80%76% and 73% at M2, M1,M3 and Ma in the season, respectively ,.The irrigation frequency reduced the initial ECe by 83% and 73% for F1 and F2 in the second season.

The effect of treatment on the ECe for the two season s at depth (30-60cm)was shown in Fig (2-a,b) farmyard manure increased the ECe by 140%,107%,and112%for m0. M1. M2.and m3 in the first season and increased it by 161%, 116%,131% and 117 for m_0, m_1, m_2,andm_3 in the second season respectively . Irrigation frequency increased the ECe by 114%,131%and 136%,188%for F_1 and F_2 respectively in the first and second season.

The statistical analysis showed that salt leaching was not significantly affected by the interaction of irrigation and farm yard manure application (M2)in The second season.

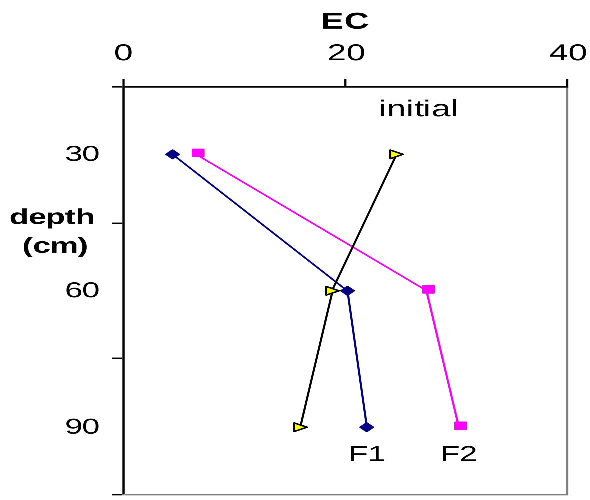

Fig. (1.a). Mean Electric conductivity as affected by Irrigation frequency, season (1)

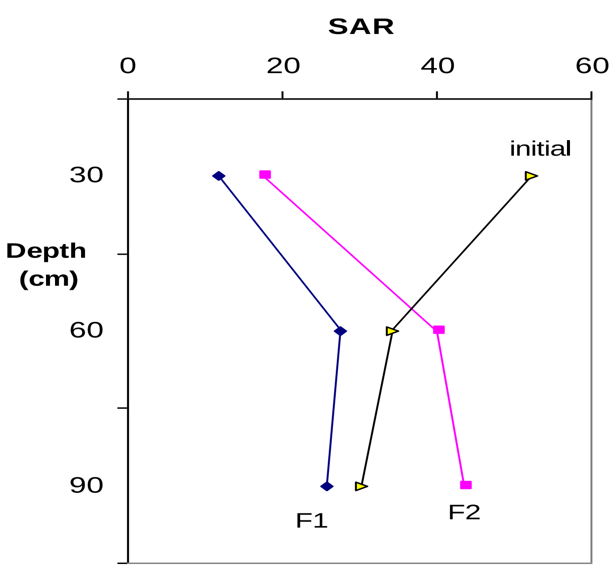

Fig. (1.b). Mean Electric conductivity as affected by Irrigation frequency, season (2)

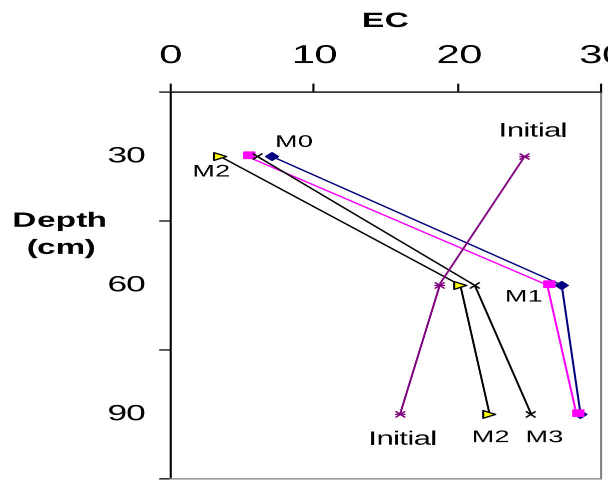

Fig. (2.a) Mean Electric conductivity as affected by Farm Yard Manure, season (1)

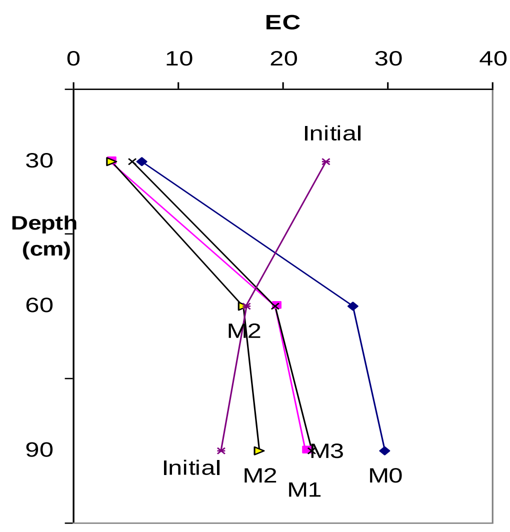

Fig. (2.b) Mean Electric conductivity as affected by Farm Yard Manure, season (2).

Fig (3a-b) reflect the data of SAR redistribution by the end of the first and second season at (0-30)cm depth.

The irrigation frequency reduced SAR by 78% in first season 72% and 63% at the end of second season by F1 and F2 respectively.

Fig (3a-b)show the effect of irrigation frequency on SAR at (30-60cm) soil depth by the end of in the first season .The initial SAR was reduced at this depth by 18% for F1,and increased by 16.6% for F2 At the end of second season it was increased by 15% and 38%, F1 and F2 respectively.

The effect of FYM on SAR in the first season was shown in Fig (4a-b),It was reduced SAR by 5% and 15% for M1and M2 respectively , and increased by 9% and 2% for M0 and M3 .

In second season SAR values were increased by 29%,18%,2% and 22% by M1,M2 and M3 respectively.

Fig.(3a-b)and (4a-b) reflect the mean sodium adsorption ratio(SAR) profile as affected by irrigation frequency and FYM in the two seasons.

The figures show that salts were leached from 0-30cm depth and accumulated at 30-90cm depth.

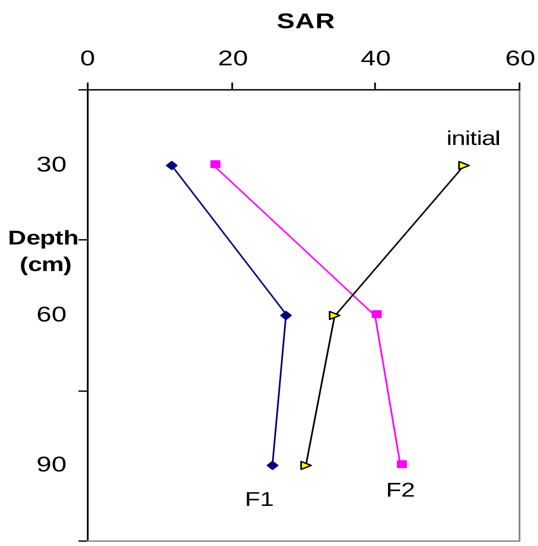

Fig. (3.a). Mean sodium adsorption ratio (SAR) profile as affected by Irrigation frequency, season (1).

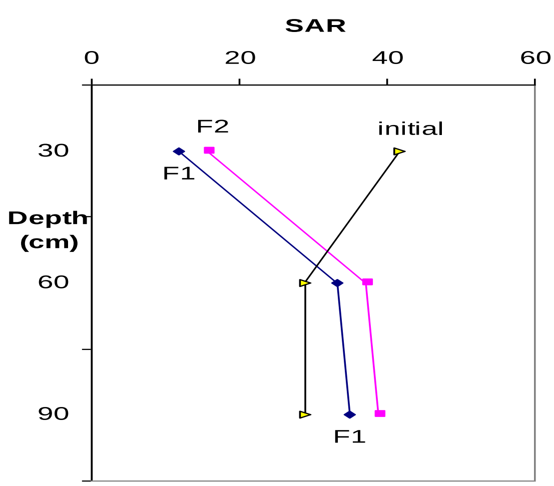

Fig. (3.b). Mean sodium adsorption ratio (SAR) profile as affected by Irrigation frequency, season (2).

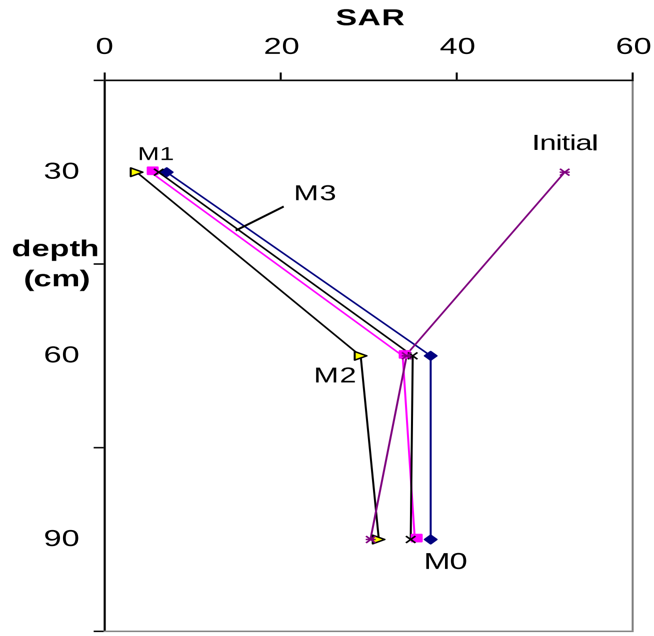

Fig. (4.a). Mean sodium adsorption ratio (SAR) profile as affected by Farm yard manure, season (1).

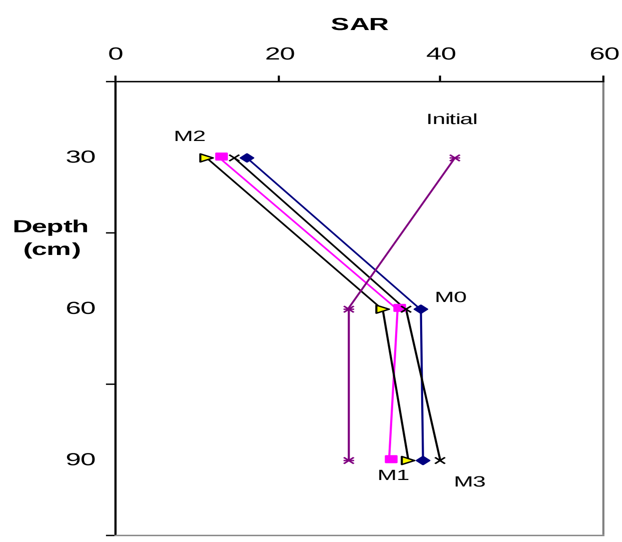

Fig. (4.b). Mean sodium adsorption ratio (SAR) profile as affected by Farm yard manure, season (2).

The result of the two seasons showed that irrigation frequency significantly recued the salinity level in the top 0-30 cm depth , but the first season data showed that SAR of the first 60 cm decreased with decrease of irrigation interval and application FYM. The good quality irrigation water would tend to dissolve these Cacompounds. The release of Ca++ ions would tend to replace Na+ ions on the exchange complex.

It is interesting to note that all treatments increased the initial ECe of the 30- 60cm layers, but reduced the initial SAR of that layer. This may be attributed to dissolution of Ca –bearing compounds which is increased with depth and possible movement of the more mobile Na+ ions to lower layers .Ma

Mustafa and Abdel Magid,(1981) reported that decreasing irrigation interval decrease ECe of the 0-40 cm zone and the ESP of the 0 -60 cm zone.

The result also showed that the 7 day of irrigation interval caused significantly better leaching than 14 day. 7 day, improved salt removal and dealkalization of the soil . these result were inline with Abdel Rahim,(1985). They found that the short irrigation interval 7 day leached salt away but Gabier,(1984) reported the advantages of the 14 days of the irrigation interval to the 7 day irrigation frequency with respect to salt leaching of the vertisoles. the result also showed that the efficiency of salt leaching is markedly affected by irrigation frequency.

The two season's data showed that FYM recued the initiaEce of the 0-30 cm depth. The salts leached from this zone were mainly accumulated at the 30-90 cm depth. the level of 10 ton per feddan (M2) which was able to reduce the salinity and sodicity more compared with the levels of application and it was considered as the best treatment.

This may be attributed to the fact that the application of FYM improved soil physically and chemically and thus enhanced salt leaching (Izzeldeen, 1995).

The first season data showed that SAR of the 60 cm decreased with the application of 10 ton per feddan. these result may be due to that FYM improved soil physical condition and soil permeability and thus there was a best leaching for the upper soil layers.

These results were in agreement with the findings of Izzeldeen 1995, and Ahmed (1989).

5. CONCOLISION:

From the above study we conclude that the use of irrigation frequency and yard manure are very effective methods in salt leaching from the upper soil layers.

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