Salt Movement from Different Depths of Salt Affected Water Tables for Clay-loam Soil under Laboratory Conditions

N. Çiftçi, Ç. Karakaş and N. Çivicioğlu

Abstract—The irrigation water from both underground and ground is not pure. The material which is included in irrigation water, especially chemicals effects irrigated soil and plant. Total arid and semi-arid regions are about 46% of total lands in the world. In those climate regions, ratio of salinity problems having different levels is almost 50% within the cultivated lands. Those problems are very serious in cultivated lands of Turkey. This study was conducted to determine the capillary salt movement from the four different salt concentrated water tables at Laboratory of Department of Farm Buildings and Irrigation, Faculty of Agriculture, University of Selcuk, Konya-Turkey. For this purpose, artificial water tables having four different salt levels namely EC=0.5 dS/m, EC=1 dS/m, EC=2 dS/m and EC=4 dS/m within the 1, 1.5 and 2 m depths were obtained. After 9 month later, capillary salt movement was determined and the soil samples were collected from 0-30, 30-60 and 60-90 cm depth in 1 m ground water level treatment; 0-30, 30-60, 60-90 and 120-150 cm depths in 1,5 m ground water level treatment; 0-30, 30-60, 60-90, 120-150 and 170-200 cm depths in 2 m ground water lever treatment. This samples were analyzed for EC, pH.

As a results, saturation extract soil concentrations was determined as 0.566-5.775 dS/m, 0.602-4.9 dS/m and 0.722-3 dS/m on the 1.0, 1,5 and 2 m ground level treatments respectively while saturation extract soil concentration was 0.458 dS/m before treatments. The highest capillary salt accumulation was obtained as 444%–1161% from water tables of 60–90 cm depth for all four treatments.

Keywords—Capillarity, Irrigation water quality, Saline soil

I. Introduction

WATER, a vital source for humanity as well as for all living things, has contributed to the formation of civilizations. Water resources are 1.36 billion km^3 in the world. Of this amount, 97.5% is saline water with only 2.5% of fresh water.

Water use is about 70%, 20% and 10% in agriculture, industry and drinking and residential usage, respectively in the world. Increase in water use has lead to reduction in water quality. Total arid and semi-arid regions are about 46% of total lands of the world. In these regions, ratio of salinity problems with different levels is almost 50% within the all cultivated lands.

Salinity is one of the main problems in cultivated lands of the world. Such problem can be seen in all climates, but much more in drought regions.

The increase of salinity in crop root zone affects directly soil yield potential. Water table reaching crop root zone or soil surface by capillary forces leaves the salts in soil profile. Especially in arid and semi-arid regions, salts in water table reaches up to soil surface by means of capillary rises.

Capillary rises followed by evaporation varies from soil hydraulic properties, climate conditions as well as cultivated crops. After irrigation, soil water content in upper parts of the soil reaches in minimum level due to the evapotranspirations. In this condition, soil moisture tension increases. Thus, capillary rises are as maximum level in field capacity but, reduces in time as a function of reduction in soil moisture (Hillel, 1980).

Some researchers such as [1] - [3] defined the saline soil as salt accumulation in upper layers of the soil from the upward movement of saline water by capillary forces from the saline water table after the evaporation process.

Turkey is arid and semi-arid climate characteristics with an annual average precipitation of almost 643 mm. The total annual water potential of Turkey is about 186 km^3. Available surface and groundwater potential of Turkey is 110 km^3 accounting of surface water potential of 98 km^3 and groundwater potential of 12 km^3 [4].

Turkey has 28 million hectares of cultivated land potential. Land potential having sloped lower than 6% is about 16.5 million hectares in Turkey. In present, 8.5% of this is economically irrigable land. The currently irrigated land is almost 5.1 million ha [5].

The land potential having salinity and alkalinity problem of Turkey is about 1 518 722 ha and this accounts of 2% of total land potential as well as 5.48% of total cultivated land and 17% of total economical irrigation areas of Turkey [6].

The cultivated land potential of Konya province is about 2 247 000 ha but, only 1 644 000 ha is irrigable area. Poor management of irrigation water management has resulted salinity, alkalinity as well as drainage problems within the irrigation areas of Konya Plain. High water table problem is present in Konya Plain. High water table level is the main

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source of saline soils [7].

The problems of salinity-alkalinity and drainage are present as 509 380 ha and 623 446 ha total lands of Konya Basin, respectively [8]. Groundwater is the main source of irrigation water in Konya Plain. Poor management of irrigation water has led to increase of water stress in irrigation, poor drainage and salt affected soils.

II. Material And Method

Konya Plain is situated in 36^o 41’- 39^o 16’ North latitude and 31^o 14’- 34^o 26’ East longitude. It is about 1016 m above the sea level [9]. In winters, weather is hard, cold with snowy, in summers it is hot and drought. It has typical semi-arid climate. Annual average temperature is about 11.5°C. The average annual rainfall is almost 316.5 mm and the highest rainfall event has observed as 43.7 mm mostly in May [10].

This study was conducted at Laboratory of Department of Farm Buildings and Irrigation, Faculty of Agriculture, University of Selcuk, Konya-Turkey. In research, plastics pipes, 12 cm in diameter with 1.0, 1.5, and 2.0 m in lengths were used at vertically position (Fig.1). Artificial water tables having four different salt concentrations were obtained.

Soils placed within the pipes were taken from the University Campus and were carried to the laboratory. Then, those soils were air- dried and then were sieved with 4 mm in diameter sieve. These soils were placed into the plastics cylinders by considering their bulk densities with equal amount of 16-24-32 kg.

Then, capillary water movements from water tables having four different salt concentrations obtained at the bottom of the cylinders were researched at 9 months period. In this experiment, total 36 cylinders were used since, 3 different water table depths, 4 different salt concentrations with 3 replications. To obtain similar water tables, equal amounts of research waters (A, B, C, D) were applied to the pots placed at bottom of each pipes. As the water amount reduces, same amount of water were added. Water amounts never allowed to be reached to the zero level. Before the experiment, following information was obtained from the research soil: soil texture: Clay-Loam; pH: 7.70; EC: 0.458 x 10^{-3} dS/m, and Bulk density: 1.42 g/cm^3.

In research, irrigation water having 4 different salt levels within the water table was used. The EC values of those waters are 0.5 dS/m obtained from municipal pipes (A), 1 dS/m (B), 2 dS/m (C) and 4 dS/m (D). B, C, D treatments were obtained from A by adding the salt.

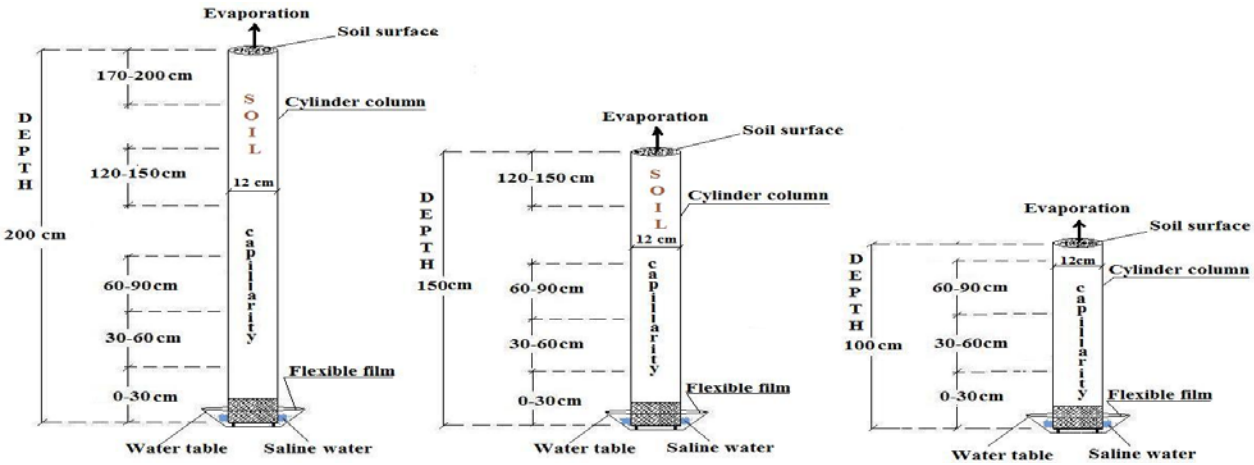

Fig. 1 Colons used in experiment

TABLE I
SOIL SALT VARIATIONS FOR DIFFERENT WATER TABLE USES IN 1.0 M DEPTH

WATER TABLE QUALITY (dS/m)	Soil Layer (cm) Above water table	pH for Saturation Extracts Averages of 3 Replications	ECx10^{-3} (dS/m) for Saturation Extracts Averages of 3 Replications	Increment by comparison before the experiment %
A	0-30	7.92	0.566	24
ECx10^{-3} = 0.5	30-60	7.94	1.617	253
	60-90	7.62	5.120	1018
B	0-30	7.95	1.245	172
ECx10^{-3} = 1	30-60	7.68	3.025	560
	60-90	7.62	5.593	1121
C	0-30	7.88	1.339	192
ECx10^{-3} = 2	30-60	7.67	2.690	487
	60-90	7.55	5.775	1161
D	0-30	7.72	2.550	457
ECx10^{-3} = 4	30-60	7.70	2.830	518
	60-90	7.46	5.625	1128

III. Conclusion

Capillary salt movements from water tables at different depths were first examined separately. These are as follows:

Capillary salt movements from water tables at different 1.0 m in depth

The salt movement and pH variations through the upward direction of soil resulted from water tables having 4 different salt concentrations in 1 m depth were presented at Table1.

As seen Table 1, in examine salt movement through the upward direction of soil resulted from water tables having 4 different salt concentrations namely A, B, C, D in 1.0 m depth, and the lowest and the highest salt movements were determined from 0-30 cm and 60-90 cm layers, respectively. The reason might be that soil moisture content is higher in areas close to the water table since during the upward direction of water table, water evaporates from water table or water losses are seen from the water table so that salt are deposited upper parts of the surface by this way.

As a result, soil was not salt affected before the experiment but at the end of the experiment, after 9 month, it was characterized as saline soil. As the water table salt concentrations increased soil salinity as well as salt movements from the water table also increased in whole layers.

Capillary salt movements from water tables at different 1.5 m in depth

The salt movement and pH variations through the upward direction of water tables having 4 different salt concentrations in 1.5 m depth were presented at Table 2.

In examine salt movement through the upward direction of soil resulted from water tables having 4 different salt concentrations namely A, B, C, D in 1.5 m depth, and the lowest and the highest salt movements were determined from 0-30 cm and 60-90 cm layers, respectively. Soil moisture content is lower in areas next to the water table so that salt concentrations in those layers were also low.

TABLE II
SOIL SALT VARIATIONS FOR DIFFERENT WATER TABLE USES IN 1.5 M DEPTH

WATER TABLE QUALITY (dS/m)	Soil Layer (cm) above water table	pH for Saturation Extracts Averages of 3 Replications	$ECx10^{-3}$ (dS/m) for Saturation Extracts Averages of 3 Replications	Increment by comparison before the Experiment %
A $ECx10^{-3} = 0.5$	0-30	7.95	0.602	31
	30-60	7.74	2.790	509
	60-90	7.50	3.150	588
	120-150	7.85	2.089	356
B $ECx10^{-3} = 1$	0-30	8.06	1.014	121
	30-60	7.69	3.177	594
	60-90	7.62	4.585	901
	120-150	7.87	2.525	451
C $ECx10^{-3} = 2$	0-30	7.92	1.541	236
	30-60	7.69	3.685	705
	60-90	7.57	4.900	970
	120-150	7.84	2.580	463
D $ECx10^{-3} = 4$	0-30	7.77	2.315	406
	30-60	7.64	3.645	696
	60-90	7.60	3.915	755
	120-150	7.80	2.410	426

TABLE III
SOIL SALT VARIATIONS FOR DIFFERENT WATER TABLE USES IN 2.0 M DEPTH

WATER TABLE QUALITY (dS/m)	Soil Layer (cm) Above water table	pH for Saturation Extracts Averages of 3 Replications	$ECx10^{-3}$ (dS/m) for Saturation Extracts Averages of 3 Replications	Increment by comparison before the experiment %
A $ECx10^{-3} = 0.5$	0-30	7.95	0.722	58
	30-60	7.62	2.250	391
	60-90	7.66	2.650	479
	120-150	7.90	1.574	244
	170-200	7.89	1.514	231
B $ECx10^{-3} = 1$	0-30	8.02	1.094	139
	30-60	7.88	2.170	374
	60-90	7.75	2.490	444
	120-150	7.80	1.833	300
	170-200	7.86	1.575	244
C $ECx10^{-3} = 2$	0-30	7.82	1.447	216
	30-60	7.69	2.605	469
	60-90	7.65	2.810	514
	120-150	7.76	1.858	306
	170-200	7.88	1.737	279
D $ECx10^{-3} = 4$	0-30	7.89	2.510	448
	30-60	7.76	2.885	530
	60-90	7.66	3.000	555
	120-150	7.73	2.303	403
	170-200	7.83	1.776	288

Capillary salt movements from water tables at different 2.0 m in depths

The salt movement and pH variations through the upward direction of soil resulted from water tables having 4 different salt concentrations in 2.0 m depth were presented at Table 3.

The highest as 444-555% and the lowest salt movement through the upward direction of soil resulted from water tables having 4 different salt concentrations in 2.0 m depth were obtained from 60-90 cm and 0-30 cm depths, respectively.

The highest increments were observed at depth for 0-90 cm water tables having 4 different salt concentrations. As the water table salt concentrations increased soil salinity as well as salt movements from the water table also increased in whole layers.

IV. Capillary Salt Movements Under Three Different Water Tables Depths

The highest salt movements from the water table in the upward directions under 3 different water tables depths having four different water table salinities were obtained from 30-90 cm depth. The highest salt increment was found at 0-30 cm layer. Soil salinity was observed greater in after the experiment by comparison to initial salt concentration of soil. Those soils closing to water table had lower salt concentrations. High salt concentration within the water table resulted high salinity within the soil profile. As the water table salt concentration increased from 0.5 dS/m (A) to 4 dS/m (D), the increment was 700% but, the increment ratio of capillary salt movement was not same ratio even they were almost close to each other.

The highest salt movements from the water table in the upward directions under 3 different water tables depths having four different water table salinities were obtained from 30-60 and 60 – 90 cm depth (Fig. 2).

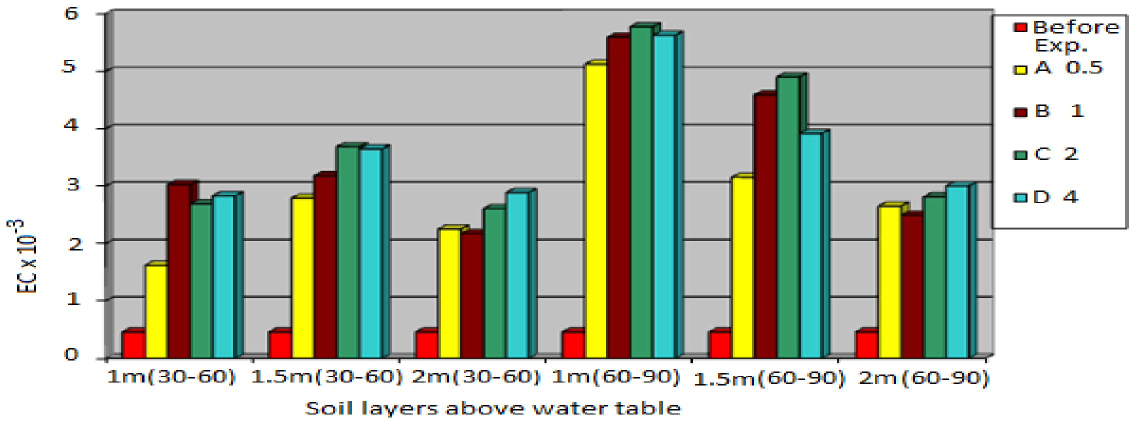

Fig. 2 ECx10^{-3} variations under 3 different water tables depths at 30-60 cm and 60-90 cm layers

As seen from fig., in A, B, C, D salt applications, total salt amount for each water table levels and layers was almost same. This can be explained that soil is one type and capillary rise is in the same amount.

In this fig., in examine the 4 different water table water quality, the highest capillary salt movement was observed in 1.0 m water table depth of 60-90 cm layer. This showed that moisture tension and capillary forces of research soils are more effective in 1.0 m water table depth.

Following recommendations should be considered in agricultural lands having high water table and high salinity:

- To control the rapid water table rises in rainy regions, agricultural drainage systems should be constructed.
- In saline soils, to leach the excess salts from the crop root zone depths, leaching water should also be applied in addition to irrigation water.
- Water table level should be controlled at 1.5m-2.0m depths from the surface especially in Clay or Clay-Loam soils by installation of agricultural drainage system.
- Soil salt concentrations should be managed regularly in areas having high water table.
- Like the other whole irrigation applications, water application efficiency should be high or losses resulted conveyance and water application processes should be minimum. Since, water table rises result from the irrigation losses and this leads to soil salinization.
- Soil-plant-water relationships should be well understood for sustainable agriculture. Proper crop selection and high quality irrigation water use and well management of irrigation water are also vital important factors for sustainable irrigation.

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