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A Research On Capillary Salt Movement From Different Salt Concentrated Water Tables Under Laboratory Conditions

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Abstract. 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 2 m depth were obtained. Capillary salt movement from those water tables was determined at the end of the 9 month. During the research, EC, and pH analysis were performed starting from the bottom parts of the soil column at the depths of 0-30, 30-60, 60-90, 120-150 and 170-200 cm depths. Although EC value of saturation extract was 0.458 dS/m before experiment, it was found as 0.722–3 dS/m after the research by increment of 58%-555%. As a result, the highest capillary salt accumulation was obtained as 444%–555% from water tables of 60–90 cm depth for all four treatments.

Keywords: Capillarity, Saline soil, Irrigation water quality

1. 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.

Some researchers such as Ergene (1982), Kwiatowsky (1998) and Kara (2002) 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 km3. 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 (Çiftçi et al. 2009).

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 (Çiftçi et al. 2010).

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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 (Sönmez, 2004).

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 source of saline soils (Çiftçi, 1987).

The problems of salinity-alkalinity and drainage are present as 509 380 ha and 623 446 ha total lands of Konya Basin, respectively (Kara et al. 1991). 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.

2. 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 (Anonymous, 2004). 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 (Anonymous, 2010).

This study was conducted at Laboratory of Department of Farm Buildings and Irrigation, Faculty of Agriculture, University of Selcuk. For this purpose, first soils taken from the University Campus were air-dried and then sieved with 4 mm in diameter sieve. Those soils were placed into the plastics cylinder (pipes) having 12 cm in diameter with 2 m length. Then, water tables having four different salt concentrations were obtained at the lower part of the cylinders to research the capillary salt movement from the salty water tables during the 9 months period. This experiment was performed at 12 cylinders by application of 4 different salt concentrations with 3 replications.

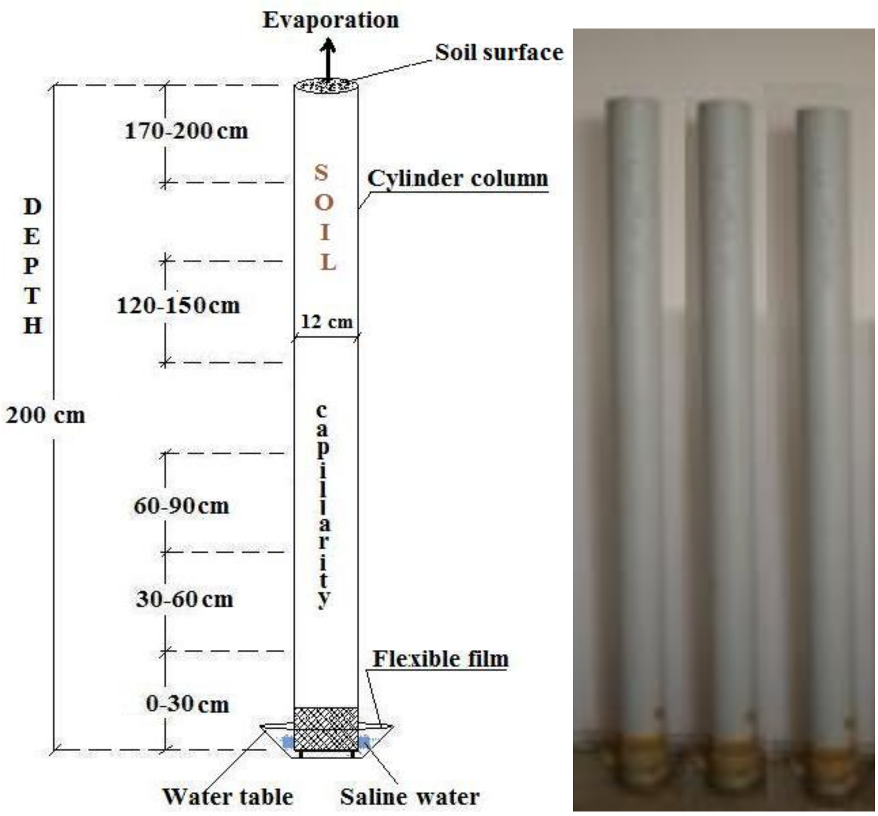

Fig. 1: A sample PVC pipe and a schematic view

Fig. 2: A sample plastic tanks having different salt concentrations

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: 0.458×10^{-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.

3. Result and Discussions

The salt movement and pH variations through the upward direction of soil resulted from 4 different salt concentrated water tables in 2 m depth were presented at Table 1.

Table 1: Soil salt variations for different water table uses

WATER TABLE QUALITY	DEPTH (cm)	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 $ECx10^{-3}$ (dS/m)=0.5	0-30	7.95	0.722	58
	30-60	7.62	2.25	391
	60-90	7.66	2.65	479
	120-150	7.90	1.574	244
	170-200	7.89	1.514	231
B $ECx10^{-3}$ (dS/m)=1	0-30	8.02	1.094	139
	30-60	7.88	2.17	374
	60-90	7.75	2.49	444
	120-150	7.80	1.833	300
	170-200	7.86	1.575	244
C $ECx10^{-3}$ (dS/m)=2	0-30	7.82	1.447	216
	30-60	7.69	2.605	469
	60-90	7.65	2.81	514
	120-150	7.76	1.858	306
	170-200	7.88	1.737	279
D $ECx10^{-3}$ (dS/m)=4	0-30	7.89	2.51	448
	30-60	7.76	2.885	530
	60-90	7.66	3	555
	120-150	7.73	2.303	403
	170-200	7.83	1.776	288

X: $ECx10^{-3}$=0.458; pH=7.70 of soils Before Experiment XX: Soil depths from starting the Water Tables

As seen Table 1, pH and EC values for A (EC=0.5 dS/m) class water table treatment varied from 7.72 to 7.95 and from 0.722 to 2.65 dS/m, respectively. By comparison to before experiment, soil salt concentrations for 0-30 cm, 30-60 cm, 60-90 cm, 120-150 cm and 170-200 cm depths from the datum water tables increased as 58%, 391%, 479%, 244% and 231%, respectively. In this treatment, the highest salt increment was found as 479% at the 60-90 cm depth. Salt variations increased rapidly as 391–479% at 30-90 cm depth but, less increment was observed as 244-231% at 120-200 cm depth.

The pH and EC values for B (EC=1 dS/m) class water table treatment varied from 7.75 to 8.02 and from 1.094 to 2.49 dS/m, respectively. By comparison to the before starting the experiment, soil salt concentrations for 0-30 cm, 30-60 cm, 60-90 cm, 120-150 cm and 170-200 cm depths from the datum water tables increased as 139%, 374%, 444%, 300% and 244%, respectively. In this treatment, the highest salt increment was found as 444% at the 60-90 cm depth. Salt variations increased rapidly as 374–444% at 30-90 cm depth but, less increment was observed as 300-244% at 120-200 cm depth.

The pH and EC values for C (EC=2 dS/m) class water table treatment varied from 7.65 to 7.88 and from 1.447 to 2.81 dS/m, respectively. By comparison to the before starting the experiment, soil salt concentrations for 0-30 cm, 30-60 cm, 60-90 cm, 120-150 cm and 170-200 cm depths from the datum water tables increased as 216%, 469%, 514%, 306% and 279%, respectively. In this treatment, the highest salt increment was found as 514% at the 60-90 cm depth. Salt variations increased rapidly as 469–514% at 30-90 cm depth but, similarly less increment was observed as 306-279% at 120-200 cm depth.

The pH and EC values for D (EC=4 dS/m) class water table treatment varied from 7.66 to 7.89 and from 1.776 to 3 dS/m, respectively. By comparison to the before starting the experiment, soil salt concentrations for 0-30 cm, 30-60 cm, 60-90 cm, 120-150 cm and 170-200 cm depths from the datum water tables increased as 448%, 530%, 555%, 403% and 288%, respectively. In this treatment, the highest salt increment was found as 555% at the 60-90 cm depth. Salt variations increased rapidly as 530-555% at 30-90 cm depth. In examine all 4 treatments (A, B, C, D), the lowest and the highest salt movement as 444-555% were obtained from 0-30 cm and 60-90 cm depths, respectively. Salt variations obtained from 0-30, 30-60, 60-90, 120-150 and 170-200 cm depths were shown in Figure 2.

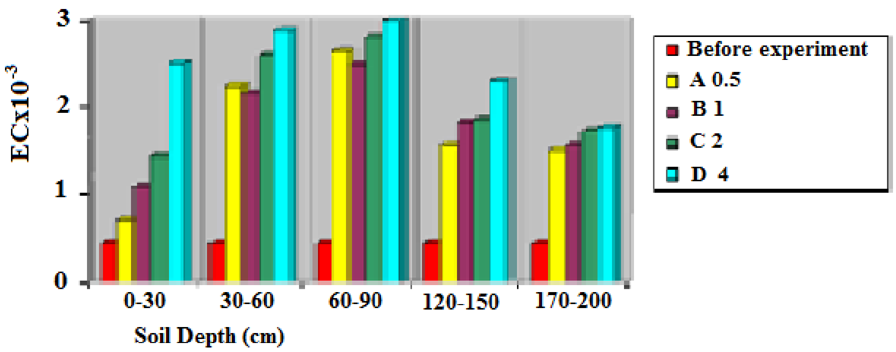

Fig. 2: Capillary salt movement for different water tables uses

As seen from Fig. 2, the highest increment for all 4 different salt concentrated water tables was found at 60-90 cm. Salt variations increased rapidly at 30-90 cm depth but less increment was observed 90-200 cm depth. The study result showed that soil was not salt affected before the experiment but at the end of the experiment, after 9 month, it was characterized as saline soil. In all layers of soils, as the salt concentration increased within water table, soil salinity also increased by movement of more salts from the water table after the experiment.

4. Recommendations

Following summary findings were obtained from the present research:

1. Although EC value for saturation extract before the experiment was 0.458 dS/m, it reached 0.722 - 3 dS/m with an increment of 58-555% at the end of the experiment.

2. In examine all 4 treatments, the lowest as 58% and the highest as 555% salt movement was found at the 0-30 cm and 60-90 cm depth. The highest capillary conductivity of Clay-Loam research soil was at 60-90 cm depth.

3. According to present research, before the experiment EC value for saturation extract was 0.458 dS/m but, application of water tables having 4 different salt concentrations during 9 month, soil was characterized as salt affected soil. The salt increment was found high as 444-555% at the 60-90 cm depth. Soil salinity level will increase dramatically by continuity availability of water table having high salts in the future.

In case of higher maximum capillary rises than potential evaporation, atmospheric effects on evaporation, soil moisture content reaches equilibrium after very short period of irrigation event and capillary rises reaches equilibrium with potential evaporation. Those findings are also agreement by following researchers (Konukcu et al. 2004; Rose et al. 2005; Gowing et al. 2006).

In conclusion, following recommendations should be considered in agricultural lands with high water table and high salinity:

1. To control the water table rises in rainy regions, agricultural drainage systems should be constructed.

2. 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 amount.

3. Water table level should never be allowed up to the 1.5m-2.0m especially in Clay or Clay-Loam soils by installation of agricultural drainage system.

4. Highly efficient pressurized irrigation systems should be used. In those systems, conveyance and application losses are very little under well water management. Thus, salinization is well controlled by this way.

5. 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. For this, farmers should be educated by research and training organizations about irrigation.

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