THE EFFECT OF PITCHER IRRIGATION ON EC AND MOISTURE SOIL IN SALINE WATER CONDITION

[1]MAHDI KEIKHA, [2]FATEMEHKARANDISH

[1]Hamoun International Wetland Research Institute University of Zabol, Iran
[2]Department of irrigation and drainage University of Zabol, Iran
E-mail: [1]MahdiKeikha@uoz.ac.ir

Abstract- The effect of pitcher irrigation on Ec and moisture soil in saline water conditions was studied in field conditions in the soil using different water Ec treatments in hot and dry weather conditions. The procedure includes three levels of salinity (5, 10 and 15 dS/m) with three replications. Suitable amounts of sodium chloride (NaCl) were dissolved in normal water for preparing saline waters. It was found that the maximum Ec of soil after irrigation was 3.18 dS/m in Ec3 treatment at 10 cm from pitcher and at a depth of 0–20 cm. Lower Ec value was measured (0.560ds/m) in the Ec1 treatment at 20 cm from pitcher depth of 40–60 cm. The maximum Ec of the soil in all treatments was at the soil surface (20 cm depth) and 10 cm from pitcher, which decreased with increasing depth of sampling. Also Ec increased with increasing distance from the center of the pitcher. Moisture measured in soil levels around the pitcher also the opposite pattern of changes in soil Ec. The maximum and minimum Percent of moisture in the soil were observed, respectively, to be 15.1% in Ec5 treatment at a depth of 40-60 cm and 10 cm from pitcher and 7.1% in the Ec3 treatment at 20 cm from pitcher and at 0-20 cm depth. The moisture content in the soil around the pitcher decreased with increasing water salinity level.

Keywords- EC, Irrigation, Moisture, Pitcher, Saline Water.

I. INTRODUCTION

The clay pot irrigation system is one of the most efficient systems of irrigation known and is ideal for many small scale farmers (Bainbridge, 2001; Mahajan *et al*, 2001; Lovell and Murata, 1998). Pitcher irrigation is an ancient technique that has been practiced in many parts of the arid world including Iran, India, African and South American countries (Mondal, 1974; Anonymous, 1997). In many developed countries high-tech micro-irrigation methods such as sprinkler and dripirrigation are used increasingly, many farmers in developing countries are reluctant to adopt these methods due to their highinitial cost of installation and costly maintenance. Traditional irrigation methods such as subsurface pitcher and porous clay pipe irrigation (Ashrafi et al., 2002; Qiaosheng et al., 2007; Siyalet al., 2009) are often preferred by poor farmers in small scale irrigation projects because of their low cost and high irrigation efficiency (Siyal, 2013).

In subsurface porous clay pipe irrigation, water and solutes not only spread downward and sideways but also move upward due to capillarity and surface evaporation, thus causing salts to accumulate at or near the soil surface. The accumulated salts may be harmful to crops that are subsequently grown at the site, especially directly seeded crops because of their sensitivity to high levels of salinity during germination and establishment (Hussain et al., 1997; Mer et al., 2000; Roberts et al., 2009). Salt accumulation during subsurface clay pipe irrigation is a particular concern in arid regions where annual potential evapotranspiration (ET) is much higher than precipitation (Siyal, 2013). Thus, special management techniques are needed to prevent salt accumulation and the resulting harmful effects on germination or seed emergence (Hanson and Bendixen, 1995; Hanson, 2003).The clay pot irrigation technology is a conservation irrigation system, which saves between 50% and 70% of water when compared to the conventional watering can irrigation system (Okalebo, *et al*, 1995). The clay pot system is therefore important when water conservation is crucial (Kefa, 2013).
The buried clay pot irrigation maintains stable soil moisture, enables crops to grow in both soil or saline soils and is suitable for using saline waters not applicable with conventional irrigation (Mondal, 1974, 1983, 1984; Alemi, 1980; Mondalet al., 1992). By using this pitcher irrigation system and unusual water, the salt accumulates in the surface of soil and the moisture in the soil around the roots, the concentration of salts in the soil around the roots is reduced (Abu-Zreig and Atoum, 2004).

II. MATERIALS AND METHODS

This study was conducted to Evaluation of salinity profile under pitcher irrigation system in the Zahak Research Station located 25 kilometers southeast of the city of Zabol (30° 53 38 N, 61° 40 49 E) with an altitude of 483 meters above sea level. The average annual rainfall of the area is 55 mm, and the annual evaporation rate is 4000 to 5000 mm. Soil texture is Sandy Loam inmainly Research Station. Soil and water chemical characteristics of the project location are presented in(table 1) and (table 2).

Table 1: Soil chemical characteristics of the test station

Depth (Cm)	Ec (ds/m)	pH	TDS (ppm)	Na (ppm)
0-50	900	7.65	1050	232.1
50-100	1140	7.8	1210	265.6

Table 2. Water chemical characteristics at experimental sites

Ec (ds/m)	pH	HCO_3	CO_3	Mg+Ca	Cl	Na
		(meq/lit)				
0.9	8.2	4.4	0	5.6	3	3.2

The procedure includes three levels of salinity (5, 10 and 15 dS/m) with three replications. Suitable amounts of sodium chloride (NaCl) were dissolved in normal water for preparing saline waters. The amount of sodium chloride to be dissolved in 1 liter of water was determined using the following relationship (1) (Michael, 1998):

Salt (mg/l) = 640 × EC (dS/ m)

Pitchers were positioned in 3 rows (each row having a set containing 3 pitchers) equidistant from each other in such a way that moisture distribution from one pitcher does not overlap with that from the other (Fig. 1). Each set of 3 pitchers in rest of the three rows was filled with water having Ec as follows: first row (Ec1) 5; second row (Ec2) 10 and third row (Ec3) 15 dS/m.Also 2 m spacing between rows and the pitchers are 0.5 m between in each row. Clay pitchers of the same shape 0.3 meters length, 0.055 meters in diameter and 0.7 liter volume. To position the pitchers in the soil, 0.6 × 0.5 m channels were drilled and pitchers with 0.5 m from each other were placed inside the channels. Pitchers are connected tanks via polyethylene hoses (Keikha et al., 2004; Bastani, 1995). Irrigation water tank was placed at a height of 2 m (Zebardast and Shafieemoghadam, 2010). To measure the salinity of the soil around the pitchers, samples were taken at 3 depths of soil after irrigation (20, 40 and 60) at 10 and 20 cm from the center of the pitcher using auger and were transported to the laboratory in plastic bags. Electrical conductivity of the soil saturation extract was determined using the portable Ec meter (Model Oakton 11) of the samples.

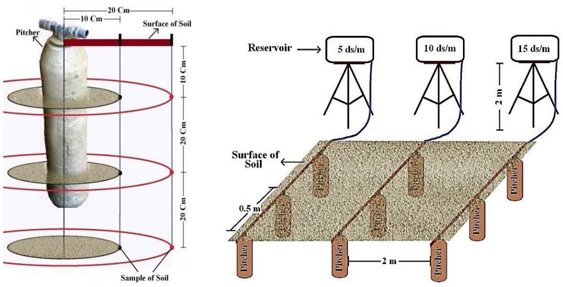

Fig1. Plan performance experiment and soil samples around the pitcher

III. RESULTS

Data analysis shows that the Ec factor between different depths (20, 40 and 60 Cm) is statistically significant ($P<0.05$) (Fig. 2). Ec is not statistically significant between Ec1 and Ec2 treatments at 10 and 20 cm from the pitcher, but Ec1 and Ec2 treatments compared with Ec3 are statistically significant ($P<0.05$).

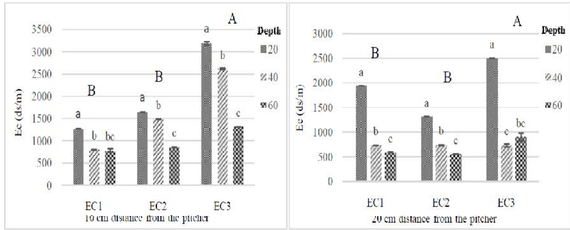

Fig2.Comparison of different water Ec treatment on soil Ec at depths of 20 to 60 cm(Small letters represents statistical significance between the different depth and capital letters represents statistical significance between the different water Ec treatments)

The Ec distribution pattern was determined for pitchers row1, 2 and 3 using saline waters of 5, 10 and 15 dS /m separately (Fig 3).

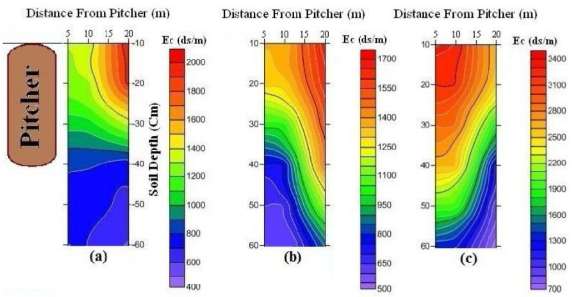

Fig3. The Ec distribution pattern around of pitcher (a, b and c are Ec1, Ec2 and Ec3 treatments, respectively)

The maximum Ec of soil after irrigation was observed (3.18 dS/m) in Ec3 treatment at 10 cm from the pitcher at a depth of 0–20 cm the minimum was observed (0.560 dS/m) in Ec1 treatment at 20 cm and at a depth of 40–60 cm. Ec changes show that the maximum amount of Ec on all treatments was observed at the soil surface (depth 20 cm) and 10 cm distance from the pitcher that because of increased evaporation from the soil surface, salinity surface to be higher compared with soil depth. Moisture content of the soil evacuated because of evaporation causes the moisture out of the soil, and salt remains in the soil (Siyal et al, 2013). With increasing depth of sampling, the Ec soil low. The percentage of depletion decreases with increasing salinity of irrigation water, which may be attributed to the higher viscosity of water with higher salinity (Naik et al, 2008). Naik et al (2008) and Siyal et al (2013) showed that the highest Ec is at a distance of 10 cm from the pitcher and a depth of 20 cm; hence, with increasing depth Ec decreases. Based on the salinity of irrigation water used in the third group (Ec3), salinity levels around the pitchers were well within the safe limit of growing crops (Naik et al, 2008).Soil Ec range for the 3 treatments at a depth of 60 cm are 0.560 to 1.975 dS/ m, 588.6 to 1641.6 dS /m and 736 to 3183.3 dS /m, respectively. Table 3 shows that there is a significant difference at the 5% level between Ec of soil in different treatments at 10 and 20 cm from the pitcher.

Table 3.Comparison of Ec soil in different distance from pitcher

Distance (Cm)	Ec (ds/m)
0-10	1252.3±72.17ᵃ
10-20	929.1±57.24ᵇ

As shown in Figure 3 when initial soil Ec (900 ds/m) and irrigation with the first treatment were compared, Ec of soil had increased 29.1% in 10 cm of the soil surface near the pitcher. But with increasing depth and seepage of water from the bottom of the pitcher, because of increased water hydraulic gradient in the pitcher (Siyal et al, 2013), Ec changes were fixed in depths of 20–60 cm of soil. Ec of soil at this depth has decreased, respectively, to 11 and 14.9% compared with initial soil Ec. Based on irrigation with Ec2 and Ec3 treatments, soil Ec has increased at the soil surface (45.1 and 71.7%, respectively) that by increasing depth the intensity of soil Ec, because of the increased flow of water pitcher, has declined sharply. Ec intensity decreased with increasing soil depth due to the increased intensity of flow of water through the pitcher.

The moisture content in the soil around the pitchers was measured at different depths and distances. Moisture was computed for 2 consecutive days (24 and 48hr after irrigation) and the results are presented in Figs. 4 and 6. The daily percentage moisture measurement with TDR. The mean soil moisture contents in the wetted zone in the vertical plane up to 60 cm depth were computed for horizontal distances of 10 and 20 cm from the pitcher. From three figures it can be seen that Ec3 yielded the lowest percentage depletion (7.1% in the Ec3 treatment at 20 cm from pitcher and at 0-20 cm depth). The highest percentage depletion, is in Ec5 (15.1% in Ec5 treatment at a depth of 40-60 cm and 10 cm from pitcher).

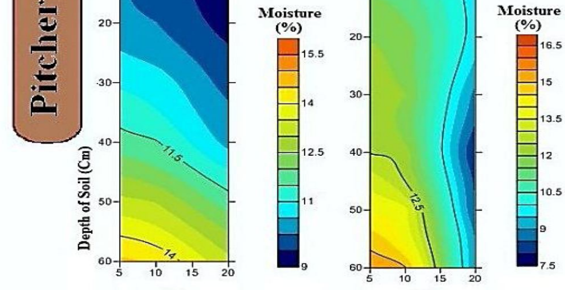

Fig4. The moisture distribution pattern around of pitcherwith salinity 5ds/m (aand b are 24 and 48 hr after irrigation, respectively)

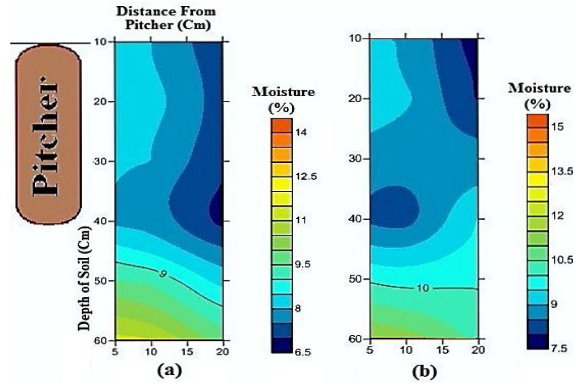

Fig5. The moisture distribution pattern around of pitcherwith salinity 10ds/m (aand b are 24 and 48 hr after irrigation, respectively)

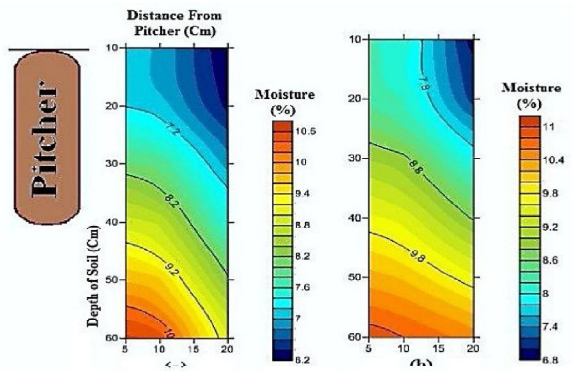

Fig6. The moisture distribution pattern around of pitcherwith salinity 15ds/m (aand b are 24 and 48 hr after irrigation, respectively)

The salinity of the water used was 5 dS/m, the mean moisture content in the soil varied between 15.1 and 9.2% from 10 to 20 cm distance. Gradually the trend decreased and at 15dS/m, it varied between 10.8 and 7.1%.The moisture content in the vertical plane increased with depth from the surface and decreased with the horizontal distance from the pitcher and moisture content in the soil around the pitcher decreased with increasing water salinity level. Also the flow rate decreased and the wetting front advance was affected, resulting in lower moisture content. The percentage depletion decreases with increasing salinity of the irrigation water which may be attributed to the higher viscosity of water with higher salinity. It also gradually decreases with time which may result from the clogging of the pitcher pores due to salt deposition.

CONCLUSION

Salt accumulation in soil because of subsurface pitcher irrigation was studied experimentally. Measured soil salinity patternshowed higher soil salinity in the soil profile above the pitcher and lower salinity around the pitcher. When salinity in all treatments observed in soil surface and at a distance of 10 cm from the pitcher was compared, surface salinity is more than the depth due to increased evaporation from the soil surface. The soil moisture evacuated due to evaporation, and salts remain in the soil. Soil salinity changes constantly with increasing depth and water leakage from the bottom of the pitcher because of increased water hydraulic gradient in the pitcher of 20–60 cm depth and then gradually declined. The moisture content in the soil around the pitcher decreased with increasing water salinity level. Salt distribution around the pitchers was observed well within the safe limit of growing crops, although initial salinity levels of water used were much higher. The study shows that pitcher irrigation may be a promising option for growing plants using highly saline waters and sustaining hardly any salinity hazard or moisture stress.

ACKNOWLEDGEMENTS

This research was supported by the Agriculture and Natural Resources Research Center of Sistan, Iran.

REFERENCES

[1] Abu-Zreig, M.M., Abe, Y., Isoda, H., 2006.The auto-regulative capability of pitcher irrigation system. Agric. Water Manage. 85 (3), 272–278.

[2] Alemi MH. 1980. Distribution of water and salt in soil under trickle and pot irrigation regimes. Agricultural Water Management 3: 195–203.

[3] Ashrafi, S., Gupta, A., Singh, M.B., Izumi, N., Loof, R., 2002.Simulation of infiltration from porous clay pipe in subsurface irrigation. Hydrological Sciences Journal 47 (2), 253–268.

[4] Bainbridge, D.A. 2001. Buried clay pot irrigation: A Little Known but very Efficient Traditional Method of Irrigation. Agricultural Water Management Journal, 48: 79-88. California.

[5] Bastani, SH. 1975. Underground irrigation using clay pipe.Forests and Rangelands Research Institute. pp. 1-20.

[6] Hanson, B.R., 2003. Drip irrigation increases tomato yields in salt-affected soil of San Joaquin Valley. California Agriculture 57, 132–137.

[7] Hanson, B.R., Bendixen, W.E., 1995. Drip irrigation controls soil salinity under row crops. California Agriculture 49 (4), 19–23.

[8] Hussain, G., Al-Jaloud, A.A., Al-Shammary, S.A., Karimulla, S., Al-Aswad, S.O., 1997.Effect of saline irrigation on germination and growth parameters of barley (Hordeum vulgare L.) in a pot experiment. Agricultural Water Management 34, 125–135.

[9] Kefa C., Kipkorir E., Kwonyike J., Kubowon P., Ndambiri .K. 2013.Comparison of Water Use Savings and Crop Yields for Clay Pot and Furrow Irrigation Methods in Lake Bogoria, Kenya.Journal of Natural Sciences Research. 3 (8) 34-39.

[10] Keikha, Gh. Akbari, H and Dahmardeh, KH. 2004. Ceramic pitcher and a culture of saving water. Proceedings of first conference inheritance of indigenous knowledge and resources.48-55.

[11] Lovell, C and Murata, M. 1998. Garden irrigation: Alternative techniques and technology diffusion in dry regions. Waterlines, 17(2): 23-26.

[12] Mahajan, S., Pednekar, P., and Patel, S. 2001. Pot Drip: An Efficient Low Cost Watering System. Waterlines, 19(4): 26-28.

[13] Mer, R.K., Prajith, P.K., Pandya, D.H., Pandey, A.N., 2000. Effect of salts on germination of seeds and growth of young plants of Hordeum vulgare, Triticumaestivum, Cicer arietinum and Brassica juncea. Journal of Agronomy and Crop Science 185, 209–217.

[14] Mondal RC, Dubey SK, Gupta SK. 1992. Use pitchers when water for irrigation is saline. Indian Horticulture 36(4): 13–15.

[15] Mondal RC. 1983. Salt tolerance of tomato grown around pitchers. Indian Journal of Agricultural Science 53 (5): 380–382.

[16] Mondal RC. 1984. Pitcher Farming Techniques for Use of Saline Waters. Annual Report, Central Soil Salinity Research Institute: Karnal, India; 1983, 18–19.

[17] Mondal, R.C., 1974. Farming with pitcher: a technique of water conservation. World Crops (262), 91–97.

[18] Naik, B.S. Panda, R.K. Nayak. S.C. Sharma. S.D., and Sahu, A.P. 2013. Impact of pitcher material and salinity of water used on flow rate, wetting front advance, soil moisture and salt distribution in soil in pitcher irrigation. Journal of irrigation and drainage. 62: 687-694.

[19] Naik, B.S. Panda, R.K. Nayak. S.C. Sharma. S.D., and Sahu, A.P. 2008. Hydraulics and salinity profile of pitcher irrigation in saline water condition. Agricultural water management.Vol (95), Issue 10, pp, 1129–1134.

[20] Okalebo JA, Mome PG, Lenga KK. 1995. Pitcher irrigation: a new irrigation technique to curb the effects of salinization. In Proceedings of the 7th Conference of the Society of Agricultural Engineers on Engineering the Economy, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya; 15–21.

[21] Qiaosheng, S., Zuoxin, L., Zhenying, W., Haijun, L., 2007.Simulation of the soil wetting shape under porous pipe sub-irrigation using dimensional analysis. Irrigation and Drainage 56, 389–398.

[22] Roberts, T.L., Lazarovitch, N., Warrick, A.W., Thompson, T.L., 2009. Modeling salt accumulation with subsurface drip irrigation using HYDRUS-2D. Soil Science Society of America Journal 73, 233–240.

[23] Sahu GS. 1995. Hydraulics and thermal behavior of irrigating pitcher, unpublished M.Tech. Thesis, Department of Soil and Water Conservation Engineering, CAET, OUAT, Bhubaneswar, Orissa.

[24] Siyal, A.A., Skaggs, T.H., 2009. Measured and simulated wetting patterns under porous clay pipe subsurface irrigation. Agricultural Water Management 96 (6), 893–904.

[25] Siyal, A.A., Van Genuchten, M., Skaggs, T.H., 2013.Solute transport in a loamy soil under subsurface porous clay pipe irrigation.Jornal of Agricultural Water Management.121 (2013) 73– 80.

[26] Vasudavan, P., Thapliyal, A., Sen, P.K., Dastidar, M.G., and Davies, P. 2011. Buried clay pot irrigation for efficient and controlled delivery.Journal of scientific & industrial research.Vol (70). pp. 645-652.

[27] Zebardast, S., and ShafieiMoghddam, A. 2010.Pitcher irrigation solution for saving water.The second national conference on the effects of drought and its management solutions. Esfahan 21 May 2010.

★★★