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Buried clay pot irrigation using saline water

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This study presents buried clay pot irrigation using saline water. Saline water solutions of different NaCl concentrations were prepared with equivalent electrical conductivity of 10, 15 and 20 dS/m and taken in buried clay pitchers. Mean daily percolation of water fell from 31 to 17% of pitcher (vol, 1.8 l) with increase in salinity of water from 10 to 20 dS/m. In the case of control water (without salinity), water percolation rate was 43%. It was observed that salt concentration in the soil increased with increasing horizontal distance from pitcher, but decreased with depth. Walls of pitchers were found partially retaining salt, indicating that water flowing out into the soil had less salinity as compared to water taken in the pitcher.

Keywords: Pitcher irrigation, Saline water, Soil salinity distribution

Introduction

Saline water has to be used in agriculture in such a way that it does not reduce quality and productivity of crops. Pitcher irrigation has been tried for saline water irrigation of different crops with good results[1-3]. Pitcher irrigation also saves up to 70% of water compared to watering with buckets and sprinkler irrigation[4]. Thus, by pitcher irrigation, root zone can be kept moist but salt distribution could be limited to levels tolerated by the plant. Distribution of salt and moisture from salt solution released by pitcher would depend on many factors such as salt water concentration, pot porosity and soil parameters. Earlier study[5] on this has brought out many interesting results and warrants further work. This study on buried clay pot irrigation using saline water investigates salt concentration in the soil with increasing horizontal distance from pitcher and with depth of pitcher, and also retaining of salt on the walls of pitchers.

Experimental Section

Pitcher Dimensions and Field Description

Clay pitchers (12) of the same shape (ht, 14 cm; maximum girth, 52.5 cm), volume (1.8 l) and wall material were brought from local potter and buried in soil up to the neck. A lid was placed on the mouth of each pitcher to avoid evaporation loss. Pitchers were installed in 4 field plots (each plot having a set containing 3 pitchers), equidistant from each other in a way that moisture distribution from one pitcher does not overlap with that from the other. NaCl solutions [electrical conductivity (EC): 10, 15 and 20 dS/m] were prepared by taking weighed amount of salt in tap water. One set of 3 pitchers in first plot was filled with tap water and used as control. Each set of 3 pitchers in rest of the three plots was filled with water having EC as follows: second plot, 10; third plot, 15; and fourth plot, 20 dS/m.

Determination of Water Depletion from Pitcher

Depletion of salt water from pitcher in 24 h was measured by refilling pitcher up to initial level (upto the neck). This was repeated over 7 days. Water loss (%) per unit time (mean daily water depletion) was calculated as[5]

$$P = \frac{100\,v}{Vt} \qquad \ldots(1)$$

where, P is water loss (%) per unit of time through pitcher wall; V, neck level capacity of pitcher (cm^3); v, volume of saline water required to fill up pitcher again to its neck level between two consecutive fillings (cm^3); and t, time elapsed between two consecutive fillings (in day, which was one day for all measurements).

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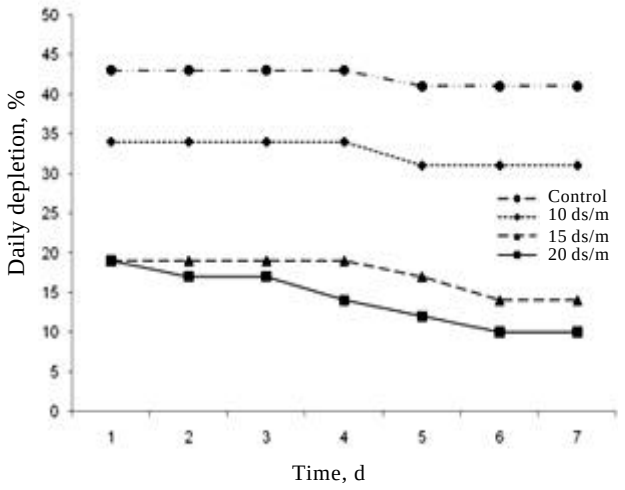

Fig. 1—Daily water depletion percentage at different concentrations of saline water

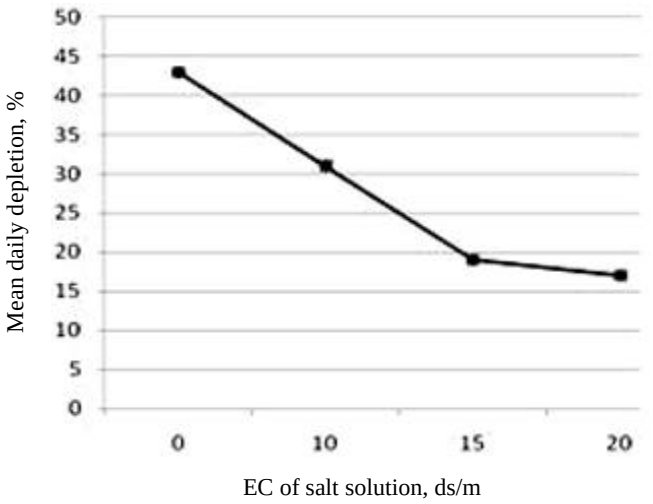

Fig. 2—Effect of salt concentration on depletion through pitcher irrigation

Determination of Salt Distribution in Soil

Salt concentration in the soil around pitcher was measured at 5, 10 and 15 cm from pitcher at vertical and horizontal distances from the maximum girth of pitcher. For this, soil (20 g) was digested with water (40 ml) and sodium ion concentration in solution was measured by flame photometry[6] to find out salt content of the soil.

Change in Salt Concentration inside Pitcher

In another set of experiments, change in salinity of residual water inside pitchers was studied by measuring salt concentration by flame photometery[6] every 24 h without adding salt solution to pitcher for making up for water depletion.

Results and Discussion

Water Depletion through Pitchers

Mean daily water depletion (P) was calculated for 7 days as per Eq. (1) for 3 pitchers in each set. Water depletion rate was found to decrease slightly with time (Fig. 1). It also decreased with increase in salt concentration. Similar results are also reported[5]. For water with different EC, average P values over 7 days were (Fig. 2): 0, 43; 10, 31; 15, 19; and 20 dS/m, 17%. One reason for decrease in flow rate with increase in salt concentration is possibly the increase in viscosity with concentration, since viscosity of aqueous solutions may be related to salt concentration as[7]

$$\eta/\eta_w = 1 + Ac^{1/2} + Bc \quad \ldots(2)$$

where η_w is viscosity of pure water and η that of aqueous salt solution, c is solute concentration, and *A* and *B* are constants characteristic of the solute. Since *A* which is an electrostatic term can be neglected at moderate concentrations, Eq. (2) can be reduced to $\eta/\eta_w = 1 + Bc$. B is a measure of ion water interaction and has a positive value for NaCl solution[8].

Salt Distribution around Pitcher

Soil salinity was found to increase when moving away from pitcher horizontally and decreased when moving away vertically downwards (Table 1). Naik *et al*[5] working up to a depth of 40 cm had reported similar trends and showed that salt concentration in the soil decreased up to a depth of 30 cm and again increased in going from 30 cm depth to 40 cm. Naik *et al*[5] also observed that moisture content at different depths increased from 0 to 30 cm, was maximum at 30 cm depth, and decreased on going down further to 40 cm depth. Thus, at 30 cm depth, moisture content was maximum and salt concentration was minimum. These trends probably reflect variations in soil water potential (soil water suction) with depth[9]. Naik *et al*[5] also reported that moisture content in soil decreased when moving away horizontally from the pot while salt in the soil increased. Thus soil salt is seen to be inversely correlated to moisture content.

Variation in Salt Concentration with Time in Pitcher

Salt content (ppm) in remaining water in buried pitcher is shown (Table 2) as a function of time (days).

Table 1—Salt distribution in the soil around pitchers

Salt conc. dS/m	Depth cm	Salt conc. at different horizontal distances from pitcher mg/kg of soil		
		5 cm	10 cm	15 cm
10	0	1280 ±2.88	1572 ±7.78	1804.8±32.14
	5	1152± 1.5	1408± 6.92	1677±23.0
	10	896±1.91	1284±6.34	1664± 23.65
	15	768±1.55	1156± 5.33	1562± 20.5
15	0	2583±1.54	3072± 6.78	3179±32.87
	5	2432±1.98	2944±7.54	3188±30.76
	10	2304 ± 1.87	2560±7.55	3046±28.66
	15	2164±1.77	2304±6.77	2562± 29.88
20	0	3844±1.35	4224±8.23	4482±30.45
	5	3710±1.87	4109±7.54	4454±28.34
	10	3456± 1.66	3968±6.54	4108±27.87
	15	3216± 1.54	3712±6.76	3968±26.80

Table 2—Change in salinity of water in the pitchers buried in soil

Time days	Salt conc., ppm		
	Pitcher I	Pitcher II	Pitcher III
0(initial)	6402	9604	12804
1	6584	10932	13650
2	8396	14738	18337
3	9120	16066	20149

Initial EC of salt solution was 10 dS/m in pitcher I, 15 dS/m in pitcher II and 20 dS/m in pitcher III. In all the cases, salinity of water in pitcher (measured by flame photometry) was seen to increase with time, indicating that pitcher wall retains salt.

Conclusions

Daily depletion (%) from buried pitchers decreased slightly with time. Mean daily depletion (%) also decreased with increase in salinity of the salt water taken. Salt distribution in soil around the pitcher increased with increase in horizontal distance from pitcher and decreased on moving vertically downwards. Salinity of residual water in pitchers increases with time showing that these pitchers have capability to retain salt.

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