EFFECT OF WATER QUALITIES ON TEMPORAL VARIATION OF FURROW BASIC INFILTRATION RATE

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ABSTRACT

The quality of irrigation water has the potential to significantly affect soil structural properties and infiltration. In this paper, water with three different levels of sodium (SAR = 0.9 as Control, 10 and 30) applied as alternative treatments to clay loam soil. The soil basic infiltration rate measured during the season using Inflow-Outflow method. Results showed that the basic infiltration rate decreased during the season. At the end of season, the soil basic infiltration rate in control treatment decreased about 34% as compared to the beginning. For the moderate and high sodic treatments, the decrease was, respectively about 45% and 61% during the season. Basic infiltration rate in all treatments showed a significantly decreasing logarithmic trend with irrigation events throughout the season.

Keywords: Soil basic infiltration rate, saline and sodic water, Furrow.

INTRODUCTION

The performance of surface (e.g. furrow, border) irrigation closely related to the infiltration function of the soil (Walker and Skogerboe 1987). However, the infiltration function has been found to vary throughout the season by a factor up to four (Elliot et al. 1983) with differences in infiltration attributed to surface sealing, variations in the soil moisture content prior to irrigation, and the effect of mulch on furrow retardation (Raine et al. 1998). These variations in infiltration, both spatial and temporal, represent a major physical constraint to achieving high irrigation application efficiencies (Shafigue and Skogerboe 1983).

Under field conditions, irrigated soils are exposed to sequential periods of rapid wetting followed by drying. Soils which are subjected to these wetting and drying cycles have been found to exhibit low aggregate stability (Caron et al. 1992; Rasiah et al. 1992) resulting in the release of colloidal material and the collapse of soil pores (Levy and Miller 1997). However, the quality of the irrigation water applied will also affect the soil chemical properties which influence soil dispersion and aggregate breakdown, surface sealing and crust formation, and changes in the infiltration function (Shainberg and Letey 1984).

Mathematical modeling of surface irrigation has played a crucial role in facilitating the research, design and management of the systems. This role became especially important with the recent advancement in computer technology.

Surface irrigation models fall into four major categories: the full hydrodynamic (e.g. Katapodes and Strelkoff 1977), the zero inertia (Sterlkoff and Katapodes 1977), the kinematics wave (Chen, 1970) and the volume balance (Lewis and Milne 1938).

Surface irrigation with water from shallow wells is utilized on approximately 40% of irrigated land in Iran. The quality of well water is variable, with some areas using water with high sodium and total electrolyte concentrations. However, the impact of water quality on the infiltration function and irrigation performance is not always recognized and the quality of water used for irrigation is not always reported. Similarly, the much of the research investigating the effect of water qualities on soil water movement and soil physical properties have been conducted under laboratory conditions using repacked soil and conditions which do not accurately represent field conditions (Shainberg and Letey 1984). The objective of the work reported here is to evaluate the effect of different water qualities on soil basic infiltration rate with considering irrigation events. In addition, temporal variation of basic infiltration rate with considering irrigation occasions using different water qualities is also reported.

MATERIAL AND METHODS

In order to determine the effects of different water qualities (salinity and sodicity) on temporal variation of basic infiltration rate, this work was conducted on the farm of Tehran University in Karaj, Iran.

The soil at the trial site has a uniform clay loam texture (dominated by illite and chlorite) overlying a semi-permeable hardpan at 60 cm. The site had been followed for more than 3 years before the implementation of the trial. Some selected initial physical and chemical properties for the trial site were measured (Table 1).

The trial work consisted of 27 irrigated furrows with 0.75m spacing, length of 30m and a slope of 0.01%. The beds were planted with maize and divided into nine plots, each consisting of three neighboring furrows. The outer furrows in each plot were used as a guard rows and all measurements were taken on the centre furrow.

Irrigation water qualities were applied at three different levels as low EC-SAR treatment (Control with EC=0.6 $dS.m^{-1}$ and SAR=0.9, *LS*), moderate EC-SAR treatment (EC=2.0 $dS.m^{-1}$ and SAR=10, *MS*) and high EC-SAR treatment (EC=6.0 $dS.m^{-1}$ and SAR=30, *HS*).

Table 1. Selected initial soil physical and chemical properties in trial site

Sand	Silt	Clay	K	p	CEC (meq/100g Soil)	pH	EC (dS/m)	depth (cm)
%			mg/kg					
29.2	45.4	25.4	204	8.2	13.0	7.9	0.56	0-30
25.2	47.4	27.4	128	3.6	13.0	7.9	0.95	30-60

SAR	Anions (meq/l)			Cations (meq/l)			Depth (cm)
	Cl^-	HCO_3^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+	
0.92	5.0	2.8	0.7	3.6	3.2	1.7	0-30
1.16	4.0	2.4	8.0	6.4	5.2	2.8	30-60

Soil basic infiltration rate was measured with Inflow-Outflow method. Irrigation water was applied to all plots at the same time on 12 irrigation occasions during the season. No rainfall was received at the site during the trial.

A complete randomized block design with 3-irrigation treatment in 3 replications was considered (including 27 irrigated furrows). Sodium chloride solutions were injected at a controlled rate into the irrigation supply pipeline to produce moderate and high SAR treatments. Irrigations were applied when the soil moisture deficit reached 50% of plant available water content (field capacity=21.9% and wilting point=9.8%) as measured using a neutron moisture meter in plots.

Kostiakov-Lewis infiltration functions in the form: $I=kt^a+f_0t$, where I is the cumulative infiltration, a and k are fitted parameters, f_o is the final infiltration rate and t is the infiltration opportunity time, were calculated for each irrigation using the irrigation advance data and the two point method (Elliott and Walker 1982). The final or basic infiltration was calculated as the difference between the furrow inflow and outflow rates (Walker and Skogerboe 1987) measured after the outflow had reached a steady state. The furrow outflow was measured using a Washington State College (WSC) flume (Chamberlain 1952). Analyses of variance (ANOVA) and paired t- test statistics used for all information data.

RESULTS AND DISCUSSION

The infiltration under field conditions was inversely related to the SAR of the applied water. Significant differences in final infiltration rate were also associated with both the number of irrigations applied and the quality of water used. The final infiltration rate (expressed as a volumetric rate per meter length of furrow) decreased from 14.6 x 10^{-5} in the beginning to 9.57 x 10^{-5} m^3/min after 12 irrigation occasions (end of period). Analysis of variance (ANOVA) regarding final infiltration variation shows that the final infiltration rates at the end of period in all treatments are located in different classes (Table 2 and 3).

Table 2. Statistical results for final infiltration rate at the end of period

Source of variation	Sum squares	Mean square	F	Significant
Treatments	٢٣,٠٧٣×١٠$^{-١٠}$	١١,٥٣٧×١٠$^{-١٠}$	٢٩,٦٩٦٦	1%
Replications	٢,٦٢١ ×١٠$^{-١٠}$	١,٣١٠ × ١٠$^{-١٠}$	٣,٣٧٣١	NS *

***:** Not Significant

Table 3. Effect of water quality on soil basic infiltration rate

Treatments	Significant (5%)		
	1	2	3
LS	9.57×10^{-5}		
MS		8.03×10^{-5}	
HS			5.677×10^{-5}

Results showed that the final infiltration rate in the end of season decreased during the season. At the end of season, the soil basic infiltration rate in control treatment decreased about 34% as compared to the beginning. For the moderate and high sodic treatments, the decrease was, respectively about 45% and 61% during the season. In addition, basic infiltration rate showed a significantly decreasing trend with irrigation events throughout the season (Fig. 1).

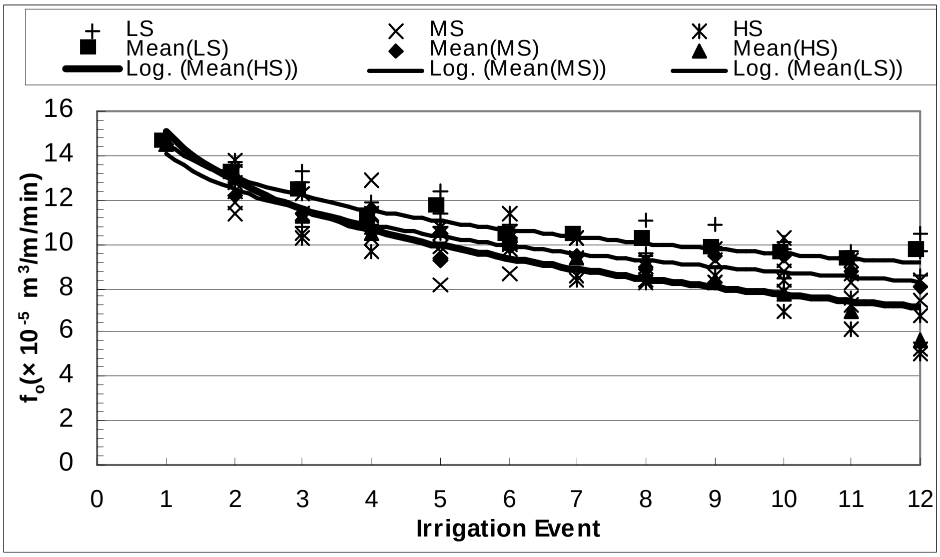

Fig. 1. Effect of water quality on final infiltration rate for sequential irrigations

All treatments showed decreasing logarithmic trend during the season (Table 4).

Table 4. Logarithmic equation for decreasing basic infiltration rate

Treatment	Equation	Standard Error
LS	$Y = (-2.161 \ln x + 14.516) \times 10^{-5}$	٢,٨ × ١٠$^{-٦}$
MS	$Y = (-2.340 \ln x + 14.110) \times 10^{-5}$	٥,٤ × ١٠$^{-٦}$
HS	$Y = (-3.205 \ln x + 15.093) \times 10^{-5}$	٦,٩ × ١٠$^{-٦}$

In addition, statistical paired t-test used for comparing significant difference trends for all treatments (Table 5).

Table 5. Paired sample statistics t-test in water quality treatments

Paired	Paired differences				t	Paired significantly
	Mean	Mean standard error	Confidence limit 95%			
			Low limit	High limit		
LS-MS	٧,٠٣٣×١٠$^{-٦}$	٢,٢٧٧×١٠$^{-٦}$	٢,٤١١×١٠$^{-٦}$	١,١٦٦×١٠$^{-٥}$	٣,٠٨٩	1%
LS-HS	١,١٦١×١٠$^{-٥}$	٢,٢٣٢×١٠$^{-٦}$	٧,٠٧٧×١٠$^{-٦}$	١,٦١٤×١٠$^{-٥}$	٥,٢٠١	1%

The moderate EC-SAR (MS) and high EC-SAR (HS) treatments, showed a significant decreasing trend (<1%) with control treatment (LS).

In addition, the mean weight parameter in the moderate and high SAR treatments decreased respectively about 17% and 53% during the irrigation season compared to control. Using higher SAR treatments also affect the soil chemical properties, which influence soil dispersion and aggregate breakdown. High SAR waters causes reduction in soil basic infiltration rate.

CONCLUSION

Irrigation water quality has been found significantly affect the soil chemical and physical properties including infiltration. These changes occurred in the presence of high solute concentrations normally associated with maintaining soil aggregate stability and continued throughout the irrigation season. The decrease in final infiltration rate with irrigation applications of moderate and high EC-SAR treatment water suggests that the change in soil physical behavior is associated with the progressive change in the chemical properties of soil solution.

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