Effect of Amendments on Hydraulic Properties of Soils Irrigated with Saline-Sodic Drainage Water: Methodology and Preliminary Results.

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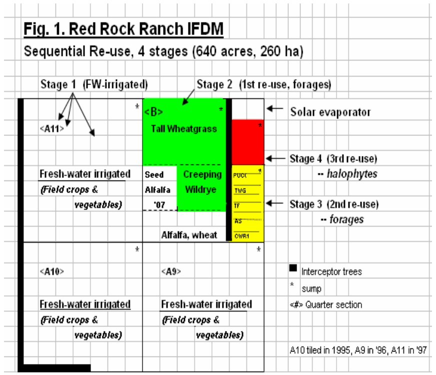
INTRODUCTION

• On the west side San Joaquin Valley (SJV) of California, agricultural drainage water (DW) from subsurface drains cannot be discharged into local waterways due to its high selenium (Se) content and potential risks to wildlife.

• In 1995, an Integrated on-Farm Drainage Management (IFDM) system was developed as a demonstration project at Red Rock Ranch (RRR) owned by John Diener (Fig. 1).



• Re-use of saline-sodic drainage water (DW) for the irrigation of salt tolerant field crops and forages is an important tool for salinity and drainage management on the Westside SJV.

• However, the sodic nature of this DW can cause clay dispersion in these soils resulting in reduced infiltration and hydraulic conductivity of water.

• Proper irrigation management and on-going soil reclamation are needed to ensure the sustainability of these DW re-use systems.

OBJECTIVES

- **Overall goal**: To evaluate the reclamation potential of gypsum, sulfur and poultry manure in improving soil hydraulic properties degraded by the long term re-use of saline-sodic drainage water in stages 3 & 4.
- **This phase**: To Characterize the unsaturated hydraulic conductivities of soils in three stages of the RRR- IFDM.

MATERIALS & METHODS

- Minidisk Infiltrometers available from Decagon Devices® (Fig. 2) were used to measure cumulative infiltration. The unsaturated hydraulic conductivities (*k*) of these soils were then calculated using the approach of Zhang (1997).
- This method required measuring cumulative infiltration vs. time and fitting the results with the equation described in "theory" box below.

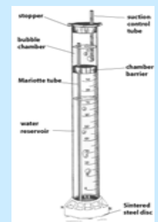


Fig:2. Infiltrometer

Theory:

The resulting measurements of infiltration vs. time are fitted with the function:

$$I = (C_1 t + C_2 \sqrt{t})$$

The hydraulic conductivity is then calculated from:

$$k = \frac{C_1}{A}$$

A is computed from:

$$A = \frac{11.65(n^{0.1}-1)\exp[2.92(n-1.9)\alpha h_o]}{(\alpha r_o)^{0.91}} \quad (n \geq 1.9)$$

or:

$$A = \frac{11.65(n^{0.1}-1)\exp[7.5(n-1.9)\alpha h_o]}{(\alpha r_o)^{0.91}} \quad (n < 1.9)$$

where n and a are the van Genuchten parameters for the soil, r_o is the disk radius, and h_o is the suction at the disk surface.

- Waters having electrical conductivities (ECw) of <1 dS/m– representing fresh (canal) water used on the farm– and 6 and 12 dS/m drainage waters were used as infiltrating water.
- Cumulative infiltration was conducted at tensions of 0.5 cm, 2 cm and 6 cm.

Above photos show infiltration measurements being taken in different stages(areas) of the RRR IFDM.

- Immediately after taking infiltration measurements, soil samples at depths of 0-5 and 0-30 cm were collected. Soil and infiltrating water samples were analyzed for EC, SAR & pH

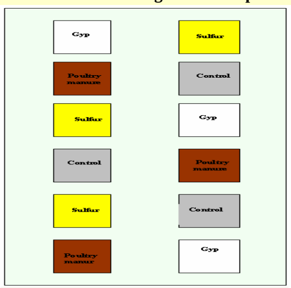


Fig. 3: Typical field layout showing the experimental plots and with randomized treatments.

- Four soil amendment treatments: gypsum (Gyp) and poultry manure at 10 ton/acre/application, sulfur at 2 ton/acre/appln. and a non-amended control were applied to 1 m^2 plots using a split plot design (Fig. 3). Each treatment was replicated three times.
- The main plot factor is the soil amendment and the sub-plot factor is the salinity of the infiltrating water (<1.0, 6, and 12 dS/m).
- Measurements began in Fall 06 (Round 1) and continue twice yearly through Spring 08. Data presented in this poster are Round 2 measurements taken in Spring 07, seven months after the first amendment application.
- Starting Fall 07, gravimetric soil moisture was also determined in each plot to determine the variation and influence of initial soil moisture on the infiltration measurements.

PRELIMINARY RESULTS

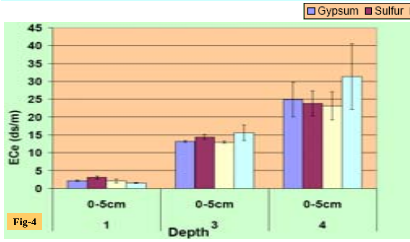


Fig. 4: soil EC values (0-5 cm depth) for three stages of the IFDM. Spring 07, after the first amendment application.

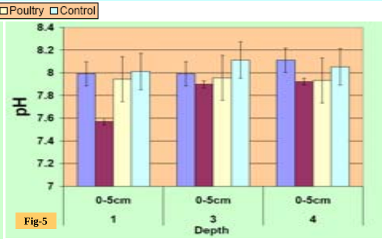


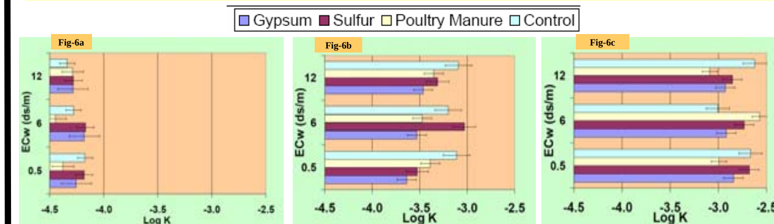
Fig. 5: soil pH values (0-5 cm depth) for three stages of the IFDM. Spring 07, after the first amendment application.

PRELIMINARY RESULTS CONT'D

Table 1: SAR of soils (0-5 cm depth) in three stages of the Red Rock Ranch IFDM

Stage	Mean	SE	Min. Value	Max. Value	CV (%)
1	1.35	0.15	0.75	2.44	39.6
3	21.9	1.06	16.7	28.8	16.7
4	56.2	5.45	33.2	96.1	33.6

Table 1: Differences in the SAR among soils in three IFDM stages (1, 3 & 4). Stage 1 and 4 represent the extremes in soil sodicity and Stage 3 is intermediate.



Graphs 6a,b,c: examples showing the Log Hydraulic Conductivity values (Spring 07, Stage 4) at 6 cm, 2 cm & 0.5 cm tensions for three water qualities.

Table 2: Example showing Hydraulic Conductivity values (Spring 07, Stage 4) at three different tensions for three different water qualities. Units = cm/sec x 10^{-4}

Tension	0.5cm			2cm			6cm		
ECw	0.5ds/m	6ds/m	12ds/m	0.5ds/m	6ds/m	12ds/m	0.5ds/m	6ds/m	12ds/m
Gypsum	14.3	12.1	11.8	2.31	2.97	3.46	1.58	2.41	2.4
Sulfur	21	18.5	14.1	2.98	9.32	4.88	3.09	2.67	2.95
Poultry	10.2	26.9	8.15	4.09	3.35	4.45	1.9	1.33	1.36
Control	21.7	19.9	23.9	7.75	6.32	8.12	2.63	1.82	1.45

SUMMARY & FUTURE WORK

- The processed data show numerical increases in hydraulic conductivity for the plots receiving the amendments in all three stages, but these differences are not statistically significant (P > 0.05). Fall 07 measurements (after 2nd amendment application) have just been completed and may reveal greater effects of the amendments on soil HC.
- A decrease in soil pH was observed, particularly in the sulfur-amended plots.
- This approach utilizing mini-disk infiltrometers to characterize hydraulic properties for undisturbed soil in the field appears to be sound and should permit us to assess the potential of various soil amendments to improve the infiltration and hydraulic conductivity of DW-irrigated soils.
- Two more rounds of measurements (Fall 07 & Spring 08) will be taken to see the overall effect of the amendments when applied twice yearly at very high rates.

References: Zhang, R. 1997. "Determination of soil sorptivity and hydraulic conductivity from the disk infiltrometer". *Soil Sci. Soc. Am. J.* 61: 1024-1030.

Jacobsen T., and L. Basinal (2004). A Landowner's Manual: Managing Agricultural Irrigation Drainage Water. A guide for developing Integrated On-Farm Drainage Management systems. Grant 319H. California State Water Resources Control Board. Hudson Orth Communications

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Cooperators: John Diener at Red Rock Ranch

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