

Leaching Fractions Achieved in South Delta Soils under Alfalfa Culture

Introduction

The Sacramento-San Joaquin Delta region is a unique agricultural region that is challenged by salinity. Soils vary in texture and permeability, and the water table is shallow. Alfalfa is a predominant crop that is flood irrigated with surface water. To prevent harmful accumulation of salts and optimize yields, soils must be leached with a quantity and quality of water that pushes salts out of the root zone. Two factors establish the required leaching: the salt concentration of the applied water and the salt sensitivity of the crop. The leaching fraction (LF) is the percent of applied water that drains below the root zone. At an irrigation water electrical conductivity (EC_w) of 1.3 dS/m, the LF necessary to maintain alfalfa yields is calculated to be 15 percent of the total applied water (Ayers and Westcot, 1985). Alfalfa is moderately sensitive to salinity, and yield reductions are expected when the soil salinity (EC_e) reaches 2.0 dS/m (Ayers and Westcot, 1985).

In the south Delta – an area southwest of Stockton, CA – the state water policy salinity objective for surface water during the irrigation season (April to August) is 0.7 dS/m, the level understood to sustain yields of beans, the most salt-sensitive crop. Salinity, however, varies over space and time, and sometimes salinity exceeds the objective. The purpose of this work is to gain knowledge on the current LF being achieved in south Delta alfalfa fields and update the state of knowledge on how surface water quality affects the LF.

Table 1. April-October irrigation water salinity (EC_w , dS/m) at seven south Delta alfalfa sites.

Site	2013		2014	
	Range	Average	Range	Average
1	0.23-0.72	0.58	0.2-0.7	0.54
2	0.45-1.01	0.75	0.7-1.2	0.89
3	0.22-0.74	0.57	0.1-0.6	0.41
4	0.33-0.77	0.47	0.5-0.7	0.57
5	0.31-2.76	1.79	1.6-3.1	1.96
6	0.61-1.06	0.86	0.6-1.1	0.88
7	0.30-0.43	0.36	0.4-0.6	0.50

Methods

- Seven commercial fields of mature alfalfa in the south Delta were selected.
- From each field, soil was sampled in the spring and fall of 2013 and 2014 from nine locations in one border check. Three of these were in the upper third of the field where irrigation water enters, three were in the middle, and three were in the lower third where irrigation drains.
- Soils were sampled at 30-cm increments to a depth of 150 cm for salinity and moisture. Soil salinity was measured using the saturated paste extract (EC_e). Groundwater salinity and depth were measured at soil sampling.
- Irrigation water was sampled from monthly irrigations (six or seven times/year) and analyzed for electrical conductivity (EC_w).
- Quadrat yield data was taken from three cuttings from nine locations in each check.

Table 2. Soil salinity (EC_e) and leaching fraction (LF) at the base of the root zone at seven south Delta alfalfa sites.

Site	Fall 2013			Fall 2014		
	Base of Root Zone	EC_e	LF	Base of Root Zone	EC_e	LF
	Depth (cm)	(dS/m)	(%)	Depth (cm)	(dS/m)	(%)
1	100	11.2	3	120	9.8	3
2	150	14.1	3	130	9.8	5
3	140	1.4	21	140	1.2	18
4	150	9.5	3	120	10.7	2
5	130	3.6	25	130	4.1	26
6	120	8.1	6	130	9.8	5
7	140	3.1	7	150	3.8	8

Table 3. Average root zone salinity (EC_e , dS/m) for seven south Delta alfalfa sites.

Site	Soil Series	Spring 2013	Fall 2013	Spring 2014	Fall 2014
1	Merritt Silty Clay Loam	4.35	6.77	5.79	7.41
2	Merritt Silty Clay Loam	7.53	8.86	8.07	7.18
3	Merritt Silty Clay Loam	1.07	0.98	0.71	0.96
4	Merritt Silty Clay Loam	4.67	5.10	4.69	5.96
5	Grangeville Fine Sandy Loam	2.10	2.40	2.77	3.13
6	Grangeville Fine Sandy Loam	5.57	5.70	5.56	6.89
7	Ryde Clay Loam	1.72	1.75	1.48	2.51

Results

Over the seasons, average EC_w ranged from 0.36-1.96 dS/m at the seven sites (Table 1).

The EC_e of the 30-cm increment above the groundwater table was considered the bottom of the root zone for the LF calculations. The achieved LF was calculated as $LF = EC_w / 2EC_e$, where EC_w is the average irrigation water salinity over the season, and $2EC_e$ is the salinity of the soil water near field capacity. The achieved LF ranged from 2-26 percent across the seven sites and sampling dates (Table 2).

Average root zone salinity was calculated as the average EC_e of the soil layers above the groundwater table (Table 3).

Alfalfa yield was not correlated with LF (data not shown).

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Salinity conditions at Site 6 in August 2013.

Summary

- In both years, three out of seven south Delta alfalfa sites had an average EC_w exceeding 0.7 dS/m, the irrigation season salinity objective set by the CA State Water Board.
- Only two sites had an average LF greater than 15 percent.
- Five sites consistently had average root zone salinity greater than 2.0 dS/m, above which yield reductions are expected. Alfalfa yield, however, was not correlated with LF, suggesting that other factors, like pest pressure or stand quality, were more influential on yield.
- These data show that irrigation water salinity may exceed the state objective, salts are building in the soil during the irrigation season, and the LF is often inadequate to leach salts in the south Delta.

Reference:

Ayers, R. S. and D. W. Westcot. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper 29 Rev. 1. FAO, United Nations, Rome. 174 p.

Acknowledgements:

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