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Use of Concentrate from Reverse Osmosis for Agricultural Use

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Introduction

Sustainable management of the highly saline concentrate resulting from reverse osmosis and other processes is a major environmental problem that limits widespread implementation of inland groundwater desalination in New Mexico and the southwestern U.S. Water is a limited resource in the southwestern United States due to low rainfall, high evaporation, low quality groundwater, and dwindling amounts of surface water. Groundwater is increasingly used to meet the water demand; however, about 75% of this water is saline (EC > 3 dS/m) and requires treatment before it is deemed potable. The Brackish Groundwater National Desalination Research Facility (BGNDRF) in Alamogordo, New Mexico uses reverse osmosis (RO) to treat saline groundwater. Using this concentrate for agriculture has the potential to eliminate the need for disposal.

Objectives

- Test the survival and growth of six plant species using the concentrate from RO
- Evaluate the transport behavior of concentrates for two soil types with contrasting texture

Figure 1 – Greenhouse setup. 144 pots (6 species, 3 treatments, 2 soils, 4 replicates) , completely randomized design.

Experimental Methods

Plant Selection:

Six salt tolerant species selected are:

Common Name	Barley	Triticale	Mesa Pepperwort	Switchgrass	Fourwing Saltbush	Inland Saltgrass
Scientific Name	*Hordeum vulgare*	*Triticum aestivum x Secale cereale*	*Lepidium alyssoides*	*Panicum virgatum*	*Atriplex canescens*	*Distichlis stricta*
Type	Food	Food	Biomass	Biomass	Fodder	Fodder

Water Treatments:

Three water treatments were prepared and mixed with a half strength Hoagland's solution. Salinity levels of the treatments varied slightly with time due to fluctuating source water salinity.

1. Irrigation water from Fabian Garcia greenhouse (~0.9 dS/m)
2. Well water from BGNDRF (~4.1 dS/m)
3. Concentrate from BGNDRF (~8.2 dS/m)

Greenhouse Experiment:

- 144 pots (6 species, 3 treatments, 2 soils, 4 replicates) packed with cheesecloth, small gravel, soil to a consistent bulk density. Repeated once but data for year I is presented here.
- Seeds planted and irrigated with control water during seedling establishment to ensure consistent growth pattern. Fertilizer added after at least one leaf had established to prevent salt burn.
- Cells arranged in completely randomized design. Treatments gradually introduced to prevent shock. Species irrigated with same volume and frequency, per soil requirement.
- Physical measurements taken at day 30, 60, 90. Photosynthetic measurements taken after day 60 and 90.
- Leaching fractions determined by collecting and measuring volume of leachate after each irrigation.

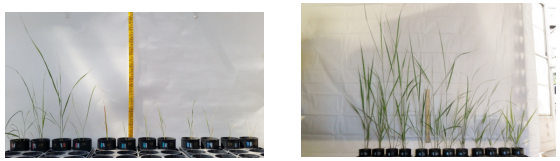
Table 1 –Influence of salinity levels on plant physiology. Barley, Inland Saltgrass, and Mesa Pepperwort showed little to no significant difference at 0.05, NS is not significant.

Clay

Fourwing Saltbush	Height (cm)		Number of Leaves		Leaf Length (cm)		Photosynthetic Rate (μmol $CO_2 m^{-2} s^{-1}$)	
Control	31.90± 2.16	a	109.00± 8.30	a	3.55± 0.22	a	7.39± 0.44	a
Well	30.18± 3.29	a	99.50± 4.76	a	4.90± 0.30	b	10.37± 0.39	b
Concentrate	32.13± 2.83	a	168.75± 13.54	b	4.60± 0.36	ab	11.51± 1.16	b
P-value	NS		0.0033		0.0495		0.0047	
Switchgrass								
Control	11.50± 1.78	a	7.50± 0.56	a	25.98± 3.12	a	15.40± 1.52	a
Well	4.00± 0.36	b	2.25± 0.22	b	14.08± 1.40	b	12.38± 0.48	ab
Concentrate	4.20± 0.83	b	2.25± 0.22	b	12.15± 1.31	b	8.43± 1.41	b
P-value	0.0047		<0.0001		0.0062		0.0195	
Triticale								
Control	10± 0.66	a	14.00± 1.27	a	27.43± 1.35	a	7.35± 0.60	a
Well	12± 0.68	a	21.25± 1.14	b	23.45± 0.75	b	13.17± 1.94	b
Concentrate	11± 0.34	a	17.00± 0.79	a	27.63± 0.32	a	11.59± 0.32	b
P-value	NS		0.0087		0.0344		0.0109	

Sand

Fourwing Saltbush	Height (cm)		Number of Leaves		Leaf Length (cm)		Photosynthetic Rate (μmol $CO_2 m^{-2} s^{-1}$)	
Control	40.2± 2.16	a	180.75± 10.08	a	3.15± 0.27	a	7.94±	0.44a
Well	45.1± 6.80	a	335.00± 36.07	b	2.48± 0.09	b	7.91±	0.57a
Concentrate	42.6± 8.33	a	306.25± 24.89	b	2.75± 0.11	ab	10.60±	1.25b
P-value	NS		0.0122		NS		NS	
Switchgrass								
Control	35.55± 5.11	a	18.75± 1.08	a	33.10± 1.33	a	8.02±	0.39a
Well	29.08± 3.31	a	19.00± 1.70	a	27.38± 3.73	a	15.59±	0.82b
Concentrate	11.50± 1.82	b	10.50± 2.28	b	17.23± 1.57	b	13.48±	0.99b
P-value	0.0081		0.0252		0.0100		<0.0001	
Triticale								
Control	36.23± 3.75	a	22.25± 2.36	a	20.33± 1.02	a	13.48±	0.70a
Well	33.13± 4.34	a	33.00± 4.14	a	18.15± 0.56	a	11.89±	0.79a
Concentrate	18.80± 3.48	b	31.25± 2.41	a	20.28± 2.69	a	11.29±	0.63a
P-value	0.0484		NS		NS		NS	



(a) (b)

Figure 2 – Salt effect was visually noticeable in Switchgrass. Species grown in clay (a) is physically stunted more than species grown in sand (b). Plants organized by increasing salinity. Other species did not show visual evidence of differences.

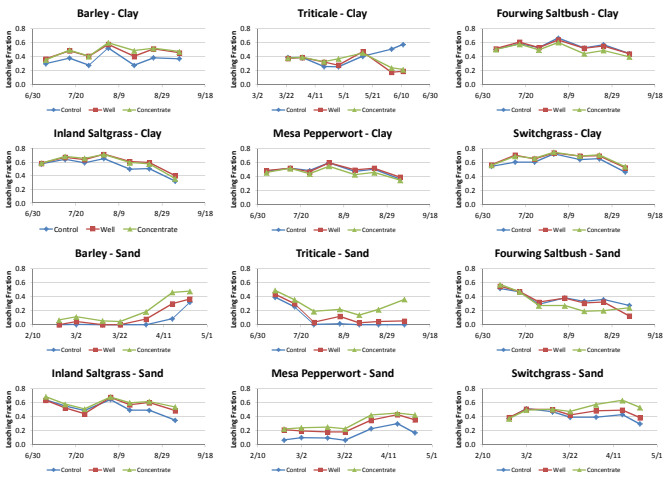


Figure 3 – Leaching fractions (volume of leachate/volume of irrigation) of all species for both soils over time.

Pore Clogging and Solute Movement:

- Two small cores (2 cm x 2 cm) were packed with each soil. Concentrate was applied until cores were saturated and then allowed to dry.
- Cores were subjected to alternate wet and dry cycles.
- Cores were analyzed with a scanning electron microscope, Hitachi S-3400N II.
- Salt deposition was observed both inside the pore and on particle surfaces
- Duel energy CT scans are proposed to distinguish between silicates and other minerals such as calcite (Pacific Northwest National Laboratory, WA)

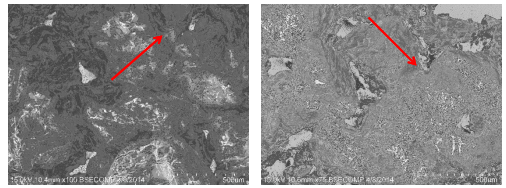


Fig 1 – Salt deposition on sand particles and in the pores.

Summary

- Barley, Triticale, Inland Saltgrass, and Mesa Pepperwort showed little to no variability due to increasing salinity treatments.
- Fourwing Saltbush showed an increase in growth with increasing salinity whereas Switchgrass showed a decrease with increasing salinity.
- Salt accumulation was evident in the pores of the sandy soil columns that could cause reductions in hydraulic conductivity of soil.

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