Irrigation Water Salinity Effects on Germination, Emergence and Growth of Halophytes

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Introduction

It has been observed that in New Mexico, agricultural irrigation demands are increasingly supplied from groundwater because the availability of surface water for irrigation are declining (Flores *et al*., 2015; Baath *et al*., 2016). According to the NM State Engineer's Office, 46 % of water for human consumption has been supplied from groundwater, and the remaining 54 % from the surface water. Agriculture water use is about 79 % of total surface and groundwater (*New Mexico First, Background Report*, 2014). In New Mexico aquifers almost 75 % of the groundwater is brackish with electrical conductivities (EC) greater than 3 dS/m, and prolonged application without treatment could increase soil salinity. Brackish groundwater can be treated by desalination through reverse osmosis (RO) at Brackish Groundwater National Desalination Research Facility (BGNDRF) in Alamogordo, NM However, after groundwater is desalinated, the environmentally safe disposal or reuse of RO concentrate water generated from an inland desalination unit is a crucial problem in New Mexico and the southwestern U.S.

Our hypotheses was that RO concentrate water can be reused for irrigating halophytes that can be used as a salt substitute in animal fodder for ensuring food security, and germination, emergence percentages and growth will not be influenced by irrigation water salinity. The objective of the experimental study was to test the germination and emergence of halophytes under an irrigation water salinity gradient.

Experimental Methods

This research was conducted in the greenhouse at Fabian Garcia Science Center in Las Cruces, New Mexico.

➢ **Plant Selection:** Six halophytes species selected were :
– *Atriplex canescens* (Pursh) Nutt. (fourwing saltbush) – *Hordeum vulgare* L. (Barley) – *Lepidium alyssoides* A. Gray (mesa pepperwort), - *Distichlis stricta* (Torr.) Rydb. (inland saltgrass) – *Panicum virgatum* L. (switchgrass), and – *Triticosecale Wittm.* (triticale).

➢ **Water Treatments:** Four water treatments selected for this study were:
- Greenhouse of Fabian Garcia Science Center irrigation tap water for the control (EC= 0.8 dS/m, SAR=2.22)
- BGNDRF brackish groundwater (EC= 5 dS/m, SAR= 4.49)
- BGNDRF RO1 concentrate (EC=8 dS/m, SAR= 5.92)
- BGNDRF RO2 concentrate (RO1 concentrate mixed with NaCl) (EC=10 dS/m, SAR=10.73)

➢ **Germination Experiment:**
- 25 seeds of each plant species seed placed on the filter papers in a petri dish were moistened with each water treatments, separately (Figure 1).
- Using an experimental set up containing randomized design of 72 petri dishes [3 (replicates) x 4 (treatments) x 6 (species)] for each of the two runs.
- Number of seeds germinated was recorded everyday and mean germination time in each petri dish was determined by following equation: $\mathrm{MGT} = \sum_{i=1}^{k}(n_i t_i) \;/\; \sum_{i=1}^{k}(n_i)$
-Final germination percentage in each petri dish was determined after 30 days by following equation:

$$\text{Germination (\%)} = \frac{\sum_{i=1}^{k} n_i}{S} * 100$$

➢ **Emergence Experiment:**
- The soil sample for the emergence experiment was collected from West Mesa, New Mexico.
- Initially, soil was air dried and then the sample was sieved through a 4 mm sieve. Afterwards, the soil sample was sterilized in an oven at a temperature of 85 °C for 30 minutes.
- The perforated cylindrical columns were packed by first putting cheese cloth at the base of the columns to prevent soil loss and then placing gravel to allow for free drainage. The columns were packed with soil at 5 cm depth increments to obtain a homogenous profile (Figure 2).
- Columns were leached with control water to bring the soil salinity of all columns to near 1 dS/m.
- Columns were irrigated with brackish groundwater, RO1 and RO2, separately, to bring the salinity of soil to that of irrigation water.
- 5 seeds of each plant species were sown within a soil depth of 1-2 cm and Irrigation water treatments were continuously applied at an interval of 2-3 days, based on the change in pot weights.
- Using an experimental set up containing randomized design of 72 cylindrical perforated columns [3 (replicates) x 4 (treatments) x 6 (species)] for each of the two runs.
- Number of seeds emerged was recorded by observation on a daily interval, mean emergence time in each columns was determined by following equation : $\mathrm{MET} = \sum_{i=1}^{k}(n_i t_i) \;/\; \sum_{i=1}^{k}(n_i)$
- Final emergence percentage in each petri dish was determined after 30 days by following equation:

$$\text{Emergence (\%)} = \frac{\sum_{i=1}^{k} n_i}{S} * 100$$

Figure 1: The petri-dishes

Figure 2: The cylindrical perforated columns

Results

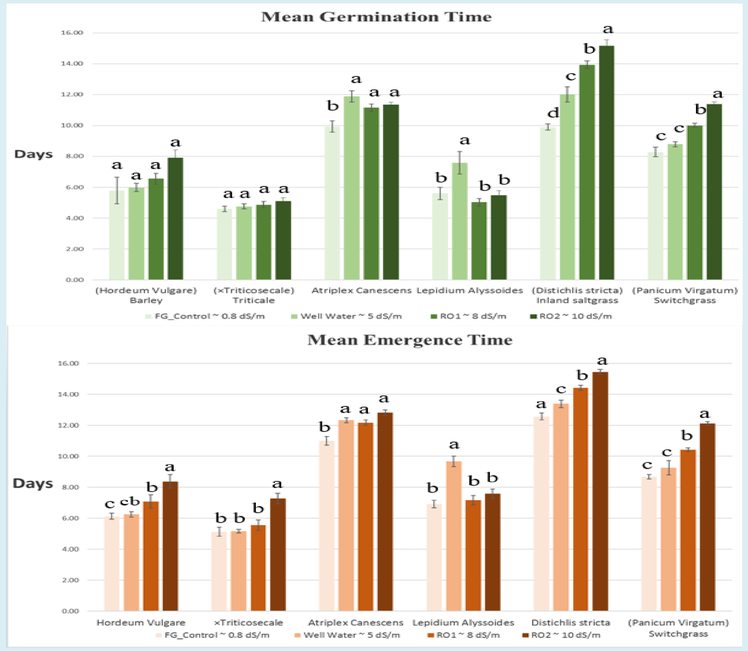

Figure 3 - Mean germination time and mean emergence time of halophytes seed of *Hordeum vulgare, xTriticosecale, Atriplex canescens, Lepidium alyssoides, Distichlis stricta, and Panicum virgatum* over 30 days, under different salt concentration treatments: EC 0.8, 5,8 and 10.0 dS/m. Within an index and within a species, values followed by different letters were significantly different at $P < 0.05$. Results are means of six replicates across two runs.

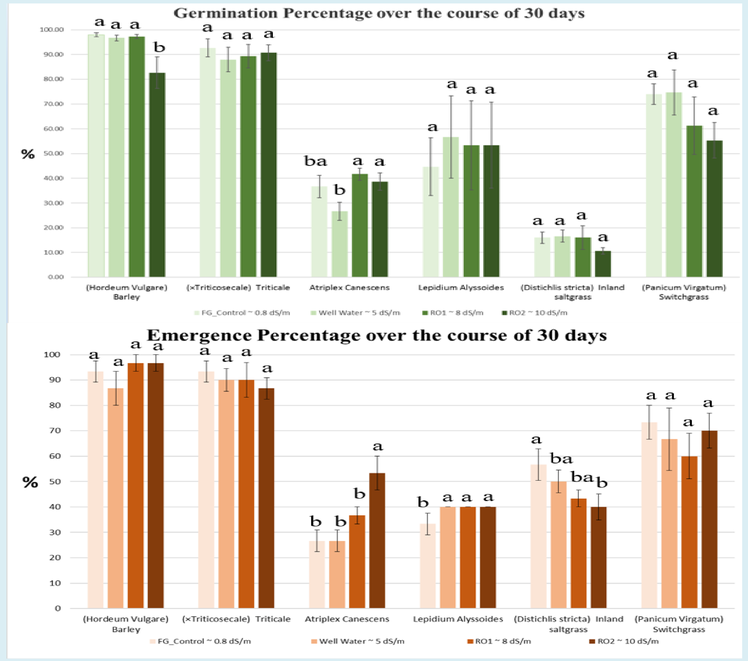

Figure 4 : Germination and Emergence percentage of halophytes seeds of *Hordeum vulgare, ×Triticosecale, Panicum virgatum, Atriplex canescens, Lepidium alyssoides*, and *Distichlis stricta* over 30 days, under different salt concentration treatments: EC 0.8, 5, 8, 10 dS/m. Within an index and within a species, values followed by different letters were significantly different at $P < 0.05$. Results are means of six replicates across two runs.

Table 1. Dry biomass yield for two halophytes. Significant difference is at a = 0.05.

		Season 1	Season 2
Species	Treatment	Dry Biomass (g) ± SE	Dry Biomass (g) ± SE
H. vulgare	EC 0.8	13.56 ± 0.52	18.14 ± 0.58 a
	EC 5	13.36 ± 1.19	18.79 ± 0.56 a
	EC 8	11.5 ± 0.91	15.17 ± 0.76 b
	EC 10	12.29 ± 1.12	19.39 ± 0.75 a
xTriticosecale	EC 0.8	12.28 ± 0.36	10.66 ± 0.38 a
	EC 5	12.31 ± 0.25	9.43 ± 0.92 ba
	EC 8	11.78 ± 0.55	7.21 ± 0.57 c
	EC 10	12.02 ± 0.42	7.70 ± 0.56 bc

Summary and Conclusions

- *H. vulgare* and *xTriticosecale*, had no significant difference statistically. Also, the *P. virgatum* seeds had no significant difference with germination under salinity treatments. The *A. canescens* seeds and *L. alyssoides* seeds showed a difference in the final germinations with higher germination percentages for the higher salinity treatments. *D. stricta* seeds displayed lower germination percentages under salinity treatments (Figure 3).
- *H. vulgare*, *xTriticosecale*, and, *P. virgatum*, had no significant difference under salinity treatments. The *L. alyssoides* and the *D. stricta* showed significant differences among water salinity treatments. For *L. alyssoides*, higher percentage emergence was observed for saline treatments than the control while for *D. stricta* seeds, it was exactly opposite. *A. canescens* showed a difference in final percent emergence with the highest emergence under EC10 (Figure 4).
- The dry biomass was not significantly different during season one for both *H. vulgare* and *xTriticosecale*. *However, in season 2, dry biomass increased for H. vulgare* but decreased for *xTriticosecale with increasing salinity (Table 1).*
- All six species are candidate species for the irrigation with high salinity water. Irrigation with RO concentrate can augment inland desalination in arid and semi-arid water scarce areas with significant amount of available brackish water.

Acknowledgements

Thanks to Nakayama Chair Endowment and Agricultural Experiment Station of NMSU. Many thanks to the Brackish Groundwater National Desalination Research Facility (BGNDRF) for providing my experiment with brackish groundwater and reverse osmosis concentrate,
Thanks to Barbara Hunter and Gurjinder Baath, Alison Flores and Jorge Fernandez for help.
Special thanks to The Ministry of National Education of Republic of Turkey for supporting my all expenses in the U.S.

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