Sustaining Riparian Vegetation Using Clinoptilolite Zeolite in an Urban Riparian Zone with Minimum Irrigation

Daniel Smith, ReNUWIt REU
Mentor: Aldo R. Pinon-Villarreal, Faculty Advisor: Dr. A. Salim Bawazir

Abstract

In arid riparian regions of the Southwestern U.S. the lack and timing of precipitation, inaccessibility to groundwater by native riparian plants due to reduced flooding, and spread of exotic opportunistic species such as saltcedar (*Tamarix* spp) have contributed to riparian ecosystem degradation. Successful revegetation in these areas is only possible by applying supplemental irrigation, recreating periodic flooding mimicking the river's historic hydrographs or by using deep planting techniques. Nevertheless, applying supplemental irrigation tends to be labor intensive and costly, and deep planting techniques are not applicable to plants with shallow root system such as grasses and some shrubs.

A riparian rehabilitation effort was undertaken to revegetate the Diez Lagos drainage canal's riparian area of nine hectares (or Sunland Park Test Bed) located near Sunland Park, NM by applying minimum irrigation and utilizing a geoengineering technique. A previous study by researchers at New Mexico State University showed that geoengineering material such as clinoptilolite zeolite (CZ) can be used to support the establishment of desirable vegetation in regions with shallow groundwater due to its ability to raise water higher than in-situ soil (e.g. sand) by capillary action. As part of this rehabilitation, the following steps were conducted in order to assess the geoengineering technique on a larger field scale: 1. transplant native riparian plants in boreholes filled with CZ as well as in unamended in situ riparian soil (RS) as control, and 2. periodically monitor plant growth and vigor. Additionally, depth to groundwater table (DGwT), soil moisture content (θ_v), growth rates, leaf chlorophyll content (LCC), and stem water potential (ψ_{stem}) were monitored. It was hypothesized that plants grown in CZ will have greater survival rates than those grown in RS.

A total of 226 plants were transplanted in the period from February 22 through April 17, 2015 along four concentric transects of variable length denoted as rehabilitation plots. Seventy-two CZ boreholes were dug with 7.62 cm-diameter augers until reaching the groundwater table and the remaining RS boreholes were dug according to the vegetation depth and backfilled with RS. The shallow boreholes ($\leq$ 2.4 m) were filled by pouring CZ mineral alternated with six liters of water up to 30 cm below the surface. For deeper boreholes, the CZ was filled up to 2.4 m above water table and the rest with a mixture of CZ and RS. Treatments were distributed into four plots having different elevations based on the DGwT, θ_v measured at 15 cm below surface (Table 1) and plant root/stem characteristics. Specimens from two tree [cottonwood (*Populus fremontii spp. Fremontii*) and black willow (*Salix nigra*)] and three shrub species [desert willow (*Chilopsis linearis*), fourwing saltbush (*Atriplex canescens*), and pale wolfberry (*Lycium pallidum*)] were transplanted into the plots while they were dormant as given by species-substrate (CZ or RS) treatments. In addition to the first irrigation applied during transplanting, all plants were irrigated three times from June 8–July 2, 2015. The irrigation events were divided according to the temperature, rainfall and θ_v occurring at the site. Every plant received on average 19–38 L of water (100–200 mm/m^2) per irrigation. Beginning in early June the survival,

growth rates, LCC and ψ_{stem} of three randomly selected plants per species-treatment per plot were determined periodically. Survival rates of the species-substrate treatments are shown in Table 2.

Table 1: Depth to groundwater table (DGwT) during transplanting and average volumetric moisture content (θ_v) measured at 15 cm below the soil surface from June 15–July 16, 2015

Plot No.	Average DGwT during transplanting, (m)	Average θv, %
1	1.68	5.3
2-3	2.18	4.0
4-Sand	3.66	2.2
4-Silt Loam	3.66	5.5

Table 2: Survival fractions (total no. of plants alive /total initial transplants) as of June 22, 2015 for all species-substrate groups per plot (-- means non planted)

	Fourwing Saltbush		Pale Wolfberry		Desert Willow	
Plot No.	Sand	CZ	Sand	CZ	Sand	CZ
1	15/24	--	10/13	11/23	12/13	3/3
2-3	0/16	4/14	1/21	--	4/9	7/12

	Cottonwood			Black Willow		
Plot No.	Sand	Silt Loam	CZ	Sand	Silt Loam	CZ
4	10/20	7/9	7/10	3/17	11/12	5/10

After one month of measurements, no significant differences in LLC and overall plant growth were observed between CZ and RS treatments for any plot. With an exception of wolfberry treatment in plot 1, CZ treatments always had greater than or equal survivorship as sand treatments. For cottonwood and black willow trees (Plot No.4), a slightly higher survival percentage was found in silt loam as compared to CZ but for the black willow, higher numbers of trees survived in silt loam. Despite low θ_v in all plots, silt loam had a higher θ_v on average. The highest mortality occurred in Plots 2-3 with an overall mortality of 73% on average. This was probably due to high temperatures during the month of June as well as consistently very low θ_v (4%). Another contributing factor to this mortality was the lack of plant root development. Measured ψ_{stem} values for plants grown in RS and CZ are shown in Figure 1. Pale wolfberry and desert willow in CZ had higher (more negative) ψ_{stem} in Plot 1. The opposite was observed in Plot 2-3. In Plot 4, the potential was highest for cottonwood grown in sand. No significant difference in ψ_{stem} among treatments was observed for black willow.

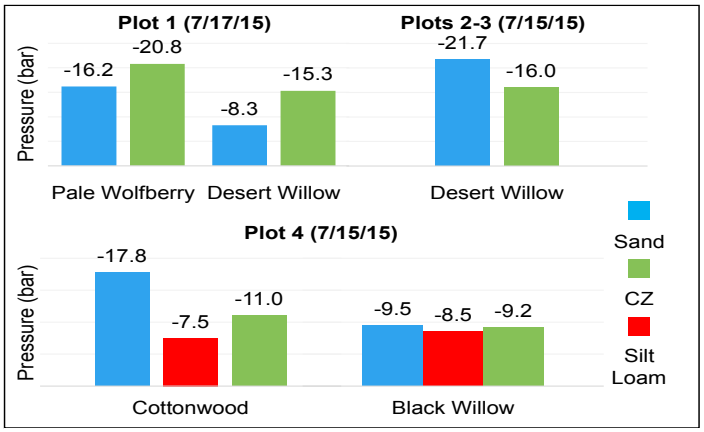

Figure 1: Stem water potential measured on three plants from each species-substrate treatment per plot

The findings reported here are preliminary due to short-term data collection and monitoring. To better assess this technique for riparian rehabilitation it is recommended to continue the long-term data collection.