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Saltbush Irrigation with Treated Wastewater

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Abstract

Saltbush grow in arid and semi-arid climates in the south as well as in the north hemisphere and shapes adapted population to different environmental conditions along with distribution. Nevertheless, there is not enough information available that allows to enhance its productive potential in abiotic stressed conditions. In this research it was determined the effect of the treated waste-water irrigation and the incorporation of organic amendment in the substrate in the development of the ecotypes 607 and 693 of Atriplex nummularia and in the ecotype 610 of *Atriplex canescens*. Treated waste-water irrigation stimulated the natural increase and the accumulation of biomass in the ecotypes 607 and 693 of *A. nummularia* and it was inhibited in the ecotype 610 of *A. canescens*, even though in no case was statistically significant. The incorporation of organic amendment into the substrate had a negative effect in the development of different ecotypes. Plants in enriched substrate with organic amendment and irrigated with treated wastewater showed the same behavior than irrigation plants only with treated wastewater. In all the cases, the ecotype 610 of *A. canescens*, showed a greater sensitivity to treatments. Results indicate that response of genus Atriplex to irrigation with treated wastewater and the incorporation to organic amendment in the substrate is dependent ecotype.

Keywords: Atriplex; Biomass; Bioenergy; Wastewater; Saltbush

Introduction

The Atriplex genre is composed by more than 200 species. Most of them show high levels of adaptation to saline soils and arid or semi-arid climate [1,2], and some species also tolerate high levels of heavy metals and are used in bioremediation of soils. [3,4]. It has proved that *A. nummularia* increased its growing rate when presence- middle levels of salinity (NaCl), and increased biomass aerial-palatable from 0.5 t ha^{-1} to 12 - 20 t ha^{-1} [5]. *A. canescens* also can be developed in saline soils (with NaCl), even though may show lower levels of adaptability in comparison with *A. nummularia, A. halimus* [6] y *A. acanthocarpa* [7]. Species of genre Atriplex is an alternative for its set up into ecosystems with water shortages, high salinity, presence of heavy metals and soils with a little nutritional content [4,8]. Climates variables define the species surviving limits and it has influence, in lower importance, in the distribution of the species [9]. The competition for water resource is a worldwide trouble, as well as the urgent needing to improve efficiency and maximize the use of the water for the agriculture production, in order to guarantee the safety of food in the future and face uncertainty in relation to climate change [10]. The main use that species of Atriplex have is in relation to reforestation plan as well as the control of erosion and animal feeding [8,11]. Also, they can be used for the production of bioenergy of second generation, its biomass has got a heating value that goes from 3548 to 4840Kcal kg^{-1} [8]. Nevertheless, there are not records about its agroforestry due to this, irrigation with treated wastewater should be examined and the incorporation of organic ammendment in the sustrate onto development of ecotypes 607 and 693 de *A. nummularia,* and the ecotype 610 de *A. canescens*, as an alternative to the production of biomass in degraded soil and desert ecosystem.

Results

The watering with Treated Sewage (T3) stimulated the growing in relation to the height of the ecotypes 607 (23.3%) and 693 (36.2%) of *A. nummularia*. and inhibited the growing of ecotypes 610 of *A. canescens* (-14.6%), in comparison with the control treatment (T1). The supplement of the substrate with 5% of organic amendment (T2) stimulated the growing in height of ecotype 693 (19.1%) *A. nummularia*, while inhibited the growing in height of ecotypes 607 of *A. nummularia* (-4.1%) y 610 de *A. canescens* (-17.8%). Irrigation with treated waste-water into substrate supplemented with a 5% of organic ammnedment (T4), estimulated the growing in height of the ecotypes 607 (23.9%) y 693 (23.6%) of *A. nummularia*, and inhibited the growing in height of ecotype 610 of *A. canescens* (-9.3%;)(Table 1).

Table 1: Plant height, stem diameter and dry biomass average of the 607 and 693 ecotypes from *A. nummularia* and of the 610 ecotypes from *A. canescens* by incorporating wastewater and/or organic amendment for its growing.

	Plant height (cm)	Stem diameter (cm)	Dry biomass (g)
607			
T1	49.4 (±13.41)	0.60 (±0.07)	6.92 (±0.66)
T2	47.4 (±7.30)	0.57 (±0.11)	6.44 (±0.68)
T3	60.9 (±17.65)	0.64 (±0.10)	8.29 (±1.25)
T4	61.2 (±16.08)	0.64 (±0.04)	8.89 (±0.99)
693			
T1	49.0 (±12.19)	0.57 (±0.05)	7.18 (±0.83)
T2	58.4 (±18.05)	0.57 (±0.07)	7.08 (±1.20)
T3	66.8 (±9.33)	0.64 (±0.04)	9.68 (±0.93)
T4	60.6 (±18.11)	0.58 (±0.03)	8.79 (±1.95)
610			
T1	37.7 (±10.19)	0.39 (±0.03)	4.79 (±1.70)
T2	31.0 (±11.34)	0.32 (±0.02)	2.96 (±0.36)
T3	32.2 (±5.88)	0.35 (±0.05)	4.03 (±1.86)
T4	34.2 (±8.76)	0.34 (±0.05)	3.25 (±0.61)

T1: Control; T2: Wastewater; T3: Organic amendments; T4: Wastewater + organic amendments.

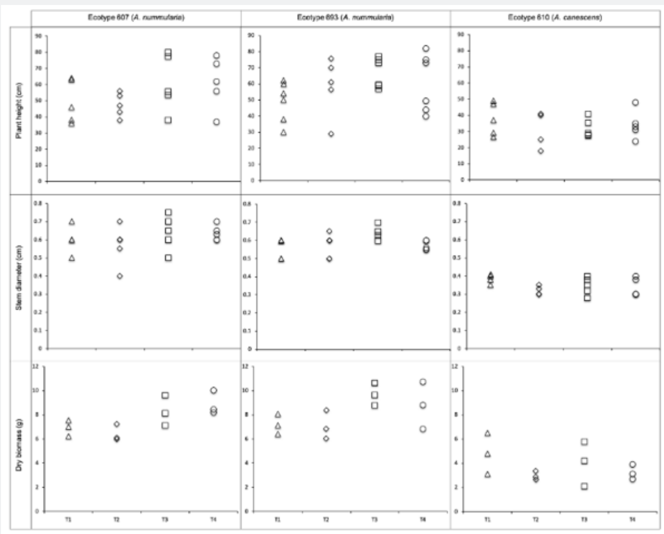

Figure 1: Plant height, stem diameter and dry biomass of the 607 and 693 ecotypes from *A. nummularia* and of the 610 ecotypes from *A. canescens* by incorporating wastewater and/or organic amendment for its growing.

T1: Control; T2: Wastewater; T3: Organic amendments; T4: Wastewater + organic amendments

Ecotype 693 of *A. nummularia*, showed the highest growth in height, with an average of 58.7cm. The maximum height was 82.0cm, and it was registered with the T4, while the least height was 29.0cm, and it was registered with T2. The ecotype 610 *A. canescens* registered the least values of growing to all treatments (Figure 1). None of the cases the differences registered were statistically significant (p>0, 05).

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Values in relation to the diameter of the steam followed the same tendency tan the growing in height according to treatments and ecotypes. The T3 induced the growing in steam diameter of the ecotypes 607 (6.6%) y 693 (12.6%) of *A. nummularia*. The T4 also induced the growing in steam diameter of the ecotypes 607 (6.0%) y 693 (1.7%) de *A. nummularia*, while the ecotype 610 of *A. canescens*, registered a decrease in the steam diameter in the T3 and T4. The T2 only stimulated the growing of the diameter of the ecotype 693 (0.6%) de *A. nummularia*, while ecotype 610 of *A. canescens* registered a decreasing in the steam diameter in the T3 and T4. The T2 only stimulated the growing of the diameter of the ecotype 693 (0.6%) de *A. nummularia*, while ecotypes 607 of *A. nummularia* and 610 of *A. canescens* showed minor steam diameter (Table 1). Ecotypes 607 and 693 of *A. nummularia*, showed a homogeneous growing according to treatments, ranging the steam diameter between 0.4 - 0.75cm, for the ecotype 607 *A. nummularia*, and 0.5 - 0.7 cm, for the ecotype 693 *A. nummularia*. The ecotype 610 of *A. canescens* registered minor diameter values (Figure 1). In any cases the differences registered were statistically significant (p>0, 05). Production of biomass showed the same pattern tan the height of the plant and the steam diameter (Table 1) The ecotypes 607 and 693 of *A. nummularia* increased the accumulation of biomass with the T3, in 19.8 and 34.9%, and with T4, in 28.4% and 22.5%, respectively. In the ecotype 610 of *A. canescens*, all the treatments inhibited the accumulation of biomass, and in the T4 the decreasing reached to 38.2% (Table 1). The ecotype 693 of *A. nummularia*, presented the highest value of vegetative growth, with a production of biomass that varied between 10.7g dry weight in T4, and 6.0g dry weight in the T2. The ecotype 610 of *A. canescens*, showed the least production of biomass. In any case the differences registered were statistically significant (p>0, 05).

Discussion

The irrigation with treated wastewater stimulated the development of the ecotypes 607 and 693 of *A. nummularia*, and was favorable its growing, independent of the highest Total Solid Contents Dissolved (TDS). Treated wastewater has a concentration of 1246 mg L^{-1} of TDS (not published). Glenn [12]. irrigate plants of *A. nummularia* with treated wastewater with 1750mg L^{-1} of TDS and did not affect their development. The treated wastewater inhibited the development of ecotype 610 of *A. canescens*, due to the fact that it is more susceptible to the content of NaCl [6]. *A. canescens* has a better adaptative response to saline soils by potassium [13], supporting lower concentrations of sodium [14]. The use of organic amendment inhibited the development of the ecotypes 607 of *A. nummularia* and 610 of *A. canescens* and had marginal impacts in the ecotype 693 de *A. nummularia*. The organic amendment used did not fulfill with regulated parameters due to the compost (not published), as the relation C/N (42) and pH (4,28), according to NCh 2880 [15]. The use of organic amendment has facilitated the establishment of A. halimus on contaminated soils with metal traces [3] and weathered [16]. Therefore, it is necessary to go deeper into studies in relation to the use of organic amendment about Atriplex, studying stabilized organic amendments, and they are available to that microorganisms can use them for feeding, releasing minerals that will be used for plants [17]. The irrigation with treated wastewater and supplemented with organic amendment, did not a synergic effect, and modulated induced response by irrigation with treated wastewater to ecotypes 607 and 693 of *A. nummularia* and 610 of *A. canescens*. The use of organic amendment inhibited the stimulating effect in the growing and development of Atriplex, caused by the irrigation by treated wastewater. Nevertheless, Peña [18] determined that the combined use of stabilized organic amendment and treated wastewater improves the performance in biomass of Lolium perenne, and hence makes possible its development in high concentrations of pesticides

Materials and Methods

Vegetative Material

There were used ecotypes number 607 and 693 of *A. nummularia*, and the ecotype 610 of *A. canescens*. Vegetative material was gotten from germoplasm field from Las Cardas Agricultural Experiment Station (30°13'S; 71°19'W), Faculty of Agricultural Sciences of the University of Chile. It was spread in the lab of Laboratorio de Bioenergía y Biotecnología Vegetal, Faculty of Agricultural Sciences of the University of Chile.

Treatments

Four treatments were done. Treatment 1 (T1) it contains based substrate composed by equal parts of peat, sand and soil and irrigation with fresh water. Treatment 2 (T2), it contains based substrate with a 5% of organic amendment, gotten from a plant of water treatment with Toha system [19] and fresh water to be used for irrigation. Treatment 3 (T3), it contains based substrate and irrigation with treated wastewater, gotten from treatment plant called Aguas Santiago Poniente S.A. [19]. Treatment 4 (T4) contains based substrate with a 5% of organic amendment and irrigation with treated wastewater. Each treatment was done with four replicas. The height of the plant was measured to 1.0cm from the point of emergency from the bud until the apex and the diameter of the stem was measured to 1.0cm from the point of emergency from the bud. Measures were carried out to 0, 30, 45, 60, 90, 120, 150 and 180 days. Once 180 days completed, total of biomass was determined produced by roots, leaves and stem by means of a destructive analysis. Samples were weighed in wet and in dry after being 72 hours in stove to 62°C [20].

Data Analysis

Levine test was carried out based in the average to determine homoscedasticity the Test of Shapiro-Wilk to determine normality, and ANOVA analysis to determine significance statics differences between treatments with secure level of 95% [21]. R commander it was used to carry out data analysis (www.r-project.org).

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Conclusions

The ecotypes 607 and 693 *A. nummularia*, could be able to establish using treated wastewater for its irrigation in areas of water-scarce in semi-arids and arid climates. Ecotype 610 of *A. canescens* did not benefit with the irrigation with treated wastewater and/or organic amendment showing a greater susceptibility in its development and less adaptation. The use of inmature organic amendment, as a suplement, inhibited the development of atriplex plants independent from the ecotype. Therefore, it is important the used organic amendment stabilized and comply with quality parameters in order to improve agroforestry production in arid and semi-arid zones.

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Author Contributions

Celián Román-Figueroa, Claudia Torres and Manuel Paneque conceived and designed this study; Jorge Figueroa executed the experimental part; Celián Román-Figueroa and Manuel Paneque wrote the paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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