Scientia Horticulturae 205 (2016) 39–44

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Short communication

Response of Daylily (*Hemerocallis hybridus* cv. 'Stella de oro') to saline water irrigation in two coastal saline soils

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ARTICLE INFO

Article history:
Received 22 January 2016
Received in revised form 4 April 2016
Accepted 12 April 2016
Available online 22 April 2016

Keywords:
Daylily
Salinity
Sandy loam
Silt
Survival rate
Dry mass

ABSTRACT

In order to evaluate the effects of irrigation water salinity, applied by drip irrigation, on Daylily (Hemerocallis hybridus cv. 'Stella de oro') growth and soil salinity, a three-year experiment was conducted in coastal saline region in Caofeidian District East China during 2013–2015 in two soils (sandy loam and silt). Five water salinity treatments were used with saline water at electrical conductivity (EC_{iw}) of 0.8, 3.1, 4.7, 6.3, and 7.8 dS/m. The original soil salinity expressed as electrical conductivity of the saturation paste extract (EC_e) was 27–30 dS/m in the 0–95 cm depth. Results showed that drip-irrigation was effective in salt leaching. The average values of soil EC_e for five treatments were 1–4 and 2–6 dS/m in 0–35 cm soil profiles of sandy loam and silt soils, respectively, after 18 months with drip irrigation. In 2014–2015, the survival rates were all >93% when irrigated with saline water at <7.8 dS/m for both saline soils. The survival rate and dry mass decreased by 0.63% and 17.14% for each unit of EC increase in the irrigation water in sandy loam saline soil, and the corresponding values were 0.70% and 25.63% in silt saline soil. This study implied that Daylily is a suitable plant in landscape construction of coastal saline soils using drip-irrigation at $EC_{iw} < 7.8$ dS/m.

1. Introduction

In China, with the rapid development of industrialization and urbanization in coastal regions, vegetation landscape construction has become a major issue and has attracted increasing awareness (Chen et al., 2015; Li et al., 2015a,b). However, it is still a challenging work as there are many saline soils and saline water around the development zone. Most of these soils cannot be initially used for landscape plants due to high levels of salt. Many methods including engineering, mechanical, chemical and biological have been used for reclamation of the coastal saline wasteland in attempts to improve the landscape, but were found ineffective due to high cost or fresh water limitation. In recent years, a regulatory method was scheduled for drip-irrigation to control the soil matric potential (SMP) and was effective in reclamation of very severely coastal saline soils, and an SMP higher above − 5 kPa at 20 cm depth under the emitter could be used as an indicator in the reclamation. The method has been successfully applied to the shrub plant (Chen et al., 2015; Li et al., 2015a,b,c). In order to extend the variety of plant types to construct a better and attractive landscape in coastal saline soils, and also extend the application of the proposed reclamation method and display its popularization, further studies are needed concerning salt tolerance of common landscape plants.

Daylily (Hemerocallis hybridus cv. 'Stella de oro') is a perennial flower and important landscaping material with good aesthetic appeal and long flowering period. It does not need extensive management, and can endure cold, hot, drought and other harsh environments. As kind of cover plant and salt-tolerant plant, Daylily has been widely applied in garden and road greening in landscape construction of coastal saline soil with freshwater irrigation (Mo, 2011). However, supplies of fresh water are already low in most coastal regions, and non-conventional water resources such as saline water, brackish ground water and treated wastewater are alternatives to fresh water resources (Rhoades et al., 1988). Saline water, rich in coastal regions, has been successfully used for irrigating landscape plants (Li et al., 2015a,b,d), and then is an ideal alternative for irrigation. Unfortunately, there is a dearth of information on Daylily subjected to salinity in field soil irrigated with saline water, and the suitable irrigation water salinity ranges were still unknown.

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http://dx.doi.org/10.1016/j.scienta.2016.04.014
0304-4238/

Table 1
Soil mechanical composition, bulk density, EC_e (electrical conductivity of saturated paste extracts), pHs (pH of saturated paste) and SAR (sodium adsorption rate of saturated paste extracts) in initial soils.

Site	Soil depth (cm)	Soil mechanical composition (%)			Soil texture	Bulk density (g/cm^3)	EC_e (dS/m)	pHs	SAR (mmol/L)$^{0.5}$
		<0.002 mm	0.002–0.05 mm	0.05–2 mm					
Eco-City	0–25	0.48	42.89	56.63	Sandy loam	1.35	27.73	7.97	54.38
	25–45	0.52	41.66	57.83		1.57	28.03	8.06	55.28
	45–95	0.55	45.36	54.09		1.69	27.31	7.88	50.28
Industrial area	0–25	0.94	80.71	18.35	Silt	1.48	29.30	7.91	56.45
	25–45	0.90	82.80	16.30		1.66	27.66	8.08	57.43
	45–95	1.16	82.64	16.20		1.68	27.08	8.03	58.30

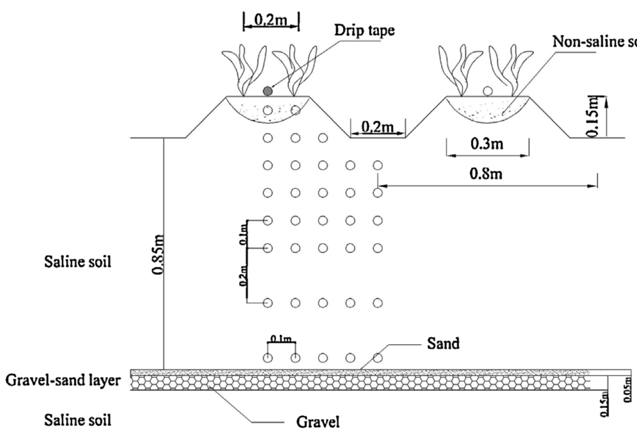

Fig. 1. Planting pattern, soil treatment and soil samplings distribution.

In this study, Daylily was planted in coastal regions with very severely sandy loam and silt saline soils, and received irrigation water at five levels of salinity using drip-irrigation. The aim of the study was to test the responses of Daylily to saline water irrigation when grown in coastal saline soils and make out the suitable irrigation water salinity ranges.

2. Materials and methods

2.1. Site description

Field experiments were conducted during 2013–2015 on coastal saline land in the Industrial Zone (39°03′N, 118°48′E) and the International Eco-City (39°20′N, 118°54′E) of Caofeidian District in the south of Tangshan city, east China, and north of Bohai Gulf which borders the Pacific Ocean. The station has a typical semi-humid monsoon climate with annual precipitation of approximately 550–580 mm, mostly during June–September. The EC_e and sodium adsorption rate (SAR) of the non-reclamation saline soils at a depth of 95 cm were 27–30 dS/m and 50–59 (mmol/L)$^{0.5}$, respectively. The soils were silt in the Eco-City and sandy loam in the Industrial Zone based on soil classification standard of USDA. The initial soil texture, soil bulk density, EC_e, pH and SAR are shown in Table 1.

2.2. Plot layout and irrigation

In this study, soil was prepared for gravel–sand layer treatment as described in Li et al. (2015a,b). That is soil was removed to a depth of 100 cm and a 15-cm thick gravel layer was laid in the bottom and then covered with a 5-cm thick layer of sand — with native soil placed back above the sand (Fig. 1). A rotary tiller was used to break clay blocks and oyster shell of the soil to increase soil infiltration. Daylily was directly planted in 8 June of 2013 and 17 July of 2013 in silt and sandy loam saline soils, respectively, and received irrigation water at five levels (0.8, 3.1, 4.7, 6.3 and 7.8dS/m) of salinity, with saline water composed by mixing fresh well-water and highly saline shallow-groundwater in different proportions. Each treatment included one plot with 3.0 m × 3.0 m, and each plot consisted of four raised (15 cm) beds. The raised bed was 0.3 m wide and 3.0 m long with 0.8 m between bed centers (Fig. 1). There are two rows of Daylily in each bed and a total of 72 strains of Daylily were planted in each plot with a spacing of 0.2 m × 0.3 m.

Each irrigation water salinity level had a separate gravity drip-irrigation system consisting of a tank (200 L) and 4 drip tubes. The tank was installed at 0.8 m above the ground to contain irrigation water. Drip tubes with 0.2-m (in sandy loam soil) and 0.3-m (in silt soil) emitter intervals were placed in the center of the beds. One vacuum gauge tensiometer was installed 0.2 m directly underneath one emitter located in the center of the plot for each treatment. The tensiometers were observed twice daily (at 8:00 and 18:00 h), and irrigation were applied when the reading value of tensiometers exceeded the target SMP value. Planting pattern, soil treatment and samplings distributions were shown in Fig. 1.

Irrigation water management was the same as described in Li et al. (2015a,b). Irrigation time was divided into two stages. The first stage was enhanced salt leaching. The second stage was water and salt regulation. Irrigation started based on soil matric potential (SMP). The target SMP value was greater than the corresponding value of SMP for field capacity in the early time, to cause a vertical downward soil water potential gradient which benefited salt leaching. Based on the experimental results of Sun et al. (2012, 2013), we set the SMP threshold at −5 kPa when the herbaceous plants were transplanted, and −10 kPa in the second year and −13 kPa in the third year combining with saving-water and soil salinity environment. The amount of water for each irrigation event was 6 mm in both soils when SMP reached the threshold value.

Irrigation started from the planting time of Daylily in 2013 and finished on 5 November of 2015. On 21–24 November of each year, 24 mm of freshwater irrigation was applied to each treatment and then irrigation was terminated until April due to the onset of winter. On 6–8 April of each year, 24 mm of freshwater irrigation was applied to each treatment to provide a suitable soil moisture environment for plant sprouting in spring, and then the irrigation begun.

2.3. Observation and measurements

The number of surviving plants was counted in 2013–2015. The shoot biomass of plants (three plants per treatment) was measured at the end of 2014. Soil cores were obtained from each plot using an auger (2.0 cm diameter, 15 cm high) before transplanting (8 June and 17 July in 2013 in silt and sandy loam soils, respectively.) and on November 2014. The samples were obtained at 0, 10, 20, 30 and 40 cm from the emitters. Soil samplings distribution was shown in Fig. 1.

All soil samples were air-dried and passed through a 1-mm sieve. Soluble salt estimates, soluble cations and soil pH were based