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Growth variables for *Vetiver zizanioides* in the hyperarid region of Sistan plain

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ABSTRACT: Adverse environmental circumstances in the Sistan plain, such as poor vegetation cover and dust, is common to the region. The aim of this study was to measure the growth parameters of *Vetiver zizanioides* in five different regions in Sistan plain in Iran. The plant variables of height and number of shoots were measured weekly as the plants were watered for all plant bases. The depth of rooting and increase in biomass were measured at the end of the study period. A total of 30 plant bases of *V. zizanioides* with three replications per treatment were planted at the beginning of March 2014 in the hyper arid region of Sistan plain. The establishment and development of the plant bases were monitored for six months. The data was analyzed in SPSS software using Duncan's test and one-way ANOVA in a completely randomized design. The results showed compatibility of planting *V. zizanioides* with the climatic conditions along the banks of Sistan river, along the drainage areas of the wastewater treatment plant and on agricultural land. No compatibility was found along the margins of drainage from agricultural land and on saline land. All variables were significantly different between the three compatible regions and the correlation between plant variables showed a significant correlation between plant height and all other variables at a 99% confidence level. The average height of *V. zizanioides* in this hyperarid region was 105 cm, but reached a maximum height of 150 cm. *V. zizanioides* is tolerant to drought and other adverse environmental circumstances are suitable species for ecological restoration of Sistan plain.

Keywords: Sistan, Hyperarid, *Vetiver zizanioides*, Compatibility

INTRODUCTION

Climatic characteristics of arid and semi-arid areas create delicate and fragile conditions along with the threat of erosion and desertification. Sistan has a hyperarid climate, lacks vegetation, and has been affected by drought and destructive climatic factors such as wind erosion. Restoration of vegetation can strongly reduce erosion and desertification in such an area.The selection of compatible plant species that are tolerant of desert conditions is essential to restore and create vegetation.

Vetiver (*Vetiver zizanioides* L. Nash) has been newly classified as *Chryspogon zizanioides* L. Nash. It has been used for bioengineering for soil stabilization and other environmental protection purposes in recent years (Truong *et al.,* 2010). It was originally developed by the World Bank for soil and water conservation in India in the mid-1980s (Truong *et al*., 2008). The World Bank promoted Vetiver grass technology as a type of environmental protection (Sabetan Fadaii *et al.,* 2011). It has been used in 120 countries to protect soil and water (Fock, 2006). It was first brought to Iran from Australia under the auspices of the Forest Rangeland and Watershed Organization in 2008. It was planted at the Kechik Research Station in Golestan province with good results (Miriniya *et al.,* 2010).

Hormuzi (2013) investigated the meteorological statistics of different provinces of Iran and found that the northern, western and southern provinces are also favorable for Vetiver cultivation. Barakati *et al.,* (2012) recommended planting Vetiver using a simple green approach that is low cost in regions with a lack of water and water resources. Sanei Dehkordi *et al.,* (2011) investigated Vetiver in two regions of Khuzestan and found that Vetiver can root and grow to acceptable height and germinate in dry regions.

Sufficient rooting root, fast growth and the quality of a plant should be considered when selecting a species suitable for planting in arid regions in addition to compatibility to use the best species for managing vegetation (Derikvand, 2012). Vetiver is resistant to drought and dryness of the soil with its deep roots and rapid growth after establishment (Nilforooshan Dardashti *et al.,* 2013). Edelstein *et al.,* (2009) stated that Vetiver has been widely planted in arid and semi-arid areas.

Vetiver soon appears as a green wall that is useful for soil and water conservation. This plant can grow in any climate (Sabetan Fadaii *et al.,* 2009). The current study for the first time, examined the growth and vegetative characteristics and features of Vetiver in arid regions of Iran. The aim of the study was to investigate the variables of growth in the hyperarid regions of Sistan plain to determine the possibility of planting it in Sistan and similar hyperarid areas. Generalization of the results can be a step toward ecological restoration of hyperarid areas.

MATERIALS AND METHODS

A. Study area

Sistan plain is located in southeastern Iran in the northern part of the province of Sistan and Baluchistan. This area is bordered on the north and east by Afghanistan and is bordered from its southwestern corner at the city of Nosratabad to its northwestern corner at the city of Nehbandan in southern Khorasan province by the Lut Desert (Green Thinkers Consulting Engineers, 2011). Sistan is a hyperarid zone in terms of climatic classification. It features intense heat (up 50°C), low rainfall (average of 59 mm), high evaporation, high elevation (4600 mm) and blowing seasonal winds (over 100 km/h) that cause wind erosion.

B. Research methodology

The location of experimental planting and research treatments were identified by investigating the features of Sistan plain. The place of primary planting was selected due to the phytoremediation of this species and was at the Wastewater Treatment Plant of the city of Zabul. The second location was along the drainage of agricultural land and the drainage of a pumping station. The third location was along the banks of the Sistan River because of the erosion of sediment and dust. The fourth are was in saline land and the fifth was in agricultural land.

The Vetiver plant bases were transferred to the designated planting sites. For each treatment, 90 holes were drilled 1.5 m apart to a depth of 50 cm. The plant bases were planted in holes and the holes were filled with the original soil and were well watered. The plants were watered and observed on a weekly basis and the rate of plant growth and changes were measured and recorded over the course of six months.

Monitoring and measurement of the establishment and growth of the plant bases was performed in cultivated areas by the separation. The parameters of plant height, number of shoots, biomass and rooting depth were recorded weekly and at the end of the study. Rooting of the plant was measured and recorded at the end of the study period to determine horizontal expansion and root penetration depth. The soil was removed from around the plant, a hole was excavated in the vicinity of the plant deep enough to uncover the roots and the deep rooting was measured. Determination of the depth of rooting was done in all five cultivated areas. The biomass of the plant was measured and recorded as wet biomass at the end of the study period. Plant weight was measured in grams.

The data was entered into SPSS software and was investigated in terms of the normal distribution (Kolmogorov-Smirnov test), homogeneity of variance (Lunz test) and the Perth and trailing amounts (boxed diagrams). The Duncan test was used at a confidence level of 95% to separate the means. The significant difference and one-way ANOVA were used after fulfillment of the assumptions of the test.

RESULTS AND DISCUSSION

The descriptive statistics of the growth variables in wastewater drainage margins, agricultural land, river banks, saline land and agricultural drainage margins are shown in Table 1. The most favorable growing conditions in the study areas were observed and recorded as agricultural land, along river banks and along wastewater drainage margins. Growth and compatibility was not favorable along the agricultural drainage margins or on saline land.

Table 2 shows the results of ANOVA. The significance level of ANOVA was found to be related to all plant variables as <0.05 and the null hypothesis was rejected. In other words, at a 5% error level, there was a significant difference in the averages of each plant variable in the different areas. The plant variables of two regions were compared using the Danken post hoc test.

Table 1: Descriptive statistics of plant variables by study region.

Plant variable	Treatment	Number	Average	SD	CV
Plant height	Wastewater margins	90	109/600	3/204	0/029
	Saline land	90	0/000	0/000	
	Agricultural drainage margins	90	0/000	0/000	
	Agricultural land	90	125/000	3/496	0/028
	River banks	90	114/500	3/028	0/026
	Total	**450**	**69/820**	**57/856**	**0/829**
Number of shoots	Wastewater margins	90	52/500	1/581	0/030
	Saline land	90	0/000	0/000	
	Agricultural drainage margins	90	0/000	0/000	
	Agricultural land	90	59/900	1/595	0/027
	River banks	90	54/700	1/494	0/027
	Total	**450**	**33/420**	**27/695**	**0/829**
Depth of rooting	wastewater margins	90	92/900	1/663	0/018
	Saline land	90	0/000	0/000	
	Agricultural drainage margins	90	0/000	0/000	
	Agricultural land	90	101/300	2/452	0/024
	River banks	90	97/000	1/491	0/015
	Total	**450**	**58/240**	**48/131**	**0/826**
Wet biomass	Wastewater margins	90	825/700	2/751	0/003
	Saline land	90	0/000	0/000	
	Agricultural drainage margins	90	0/000	0/000	
	Agricultural land	90	894/700	3/335	0/004
	River banks	90	874/600	3/204	0/004
	Total	450	519/000	428/670	0/826

Table 2: Variance in plant variables.

Plant variable	Fisher statistic	Significance
Plant height	6465/393	<0/001
Number of shoots	6444/048	<0/001
Depth of rooting	12888/195	<0/001
Wet biomass	388694/295	<0/001

The results presented in Table 3 indicate that the average plant height, number of shoots, depth of rooting and wet biomass were significantly different for the saline land and agricultural drainage margins, but the other areas showed mutually significant differences (their average for different categories).

Pearson correlation coefficient values were calculated between two plant variables and are recorded in Table 4. The results of the correlation coefficient test are reported with the level of significance (p-value). Significant correlations at an error level of one percent are marked with (**) symbols. The first row shows that there was a significant relationship between plant height and all other variables at an error level of one percent.

Table 3: Results of Duncan's post hoc test to compare vegetative variables in the study area.

Plant variable	Number	Agricultural land	River banks	Wastewater drainage margins	Saline land	Agricultural drainage margins
Plant height	90	125/000	114/500	109/600	0/000	0/000
Number of shoots	90	59/900	54/700	52/500	0/000	0/000
Depth of rooting	90	101/300	97/000	92/900	0/000	0/000
Wet biomass	90	894/700	874/600	852/700	0/000	0/000

Table 4: Pearson correlation coefficient and its significance test for plant variables.

Plant variable		Plant height	Number of shoots	Depth of rooting	Wet biomass
Plant height	Correlation	1	1/000**	0/999**	0/998**
	p-value		<0/001	<0/001	<0/001
Number of shoots	Correlation	1/000**	1	0/999**	0/998**
	p-value	<001/0		<0/001	<0/001
Depth of rooting	Correlation	0/999**	0/999**	1	000/1**
	p-value	<001/0	<001/0		<0/001
Wet biomass	Correlation	0/998**	0/998**	1/000**	1
	p-value	<001/0	<001/0	<001/0	

The depth of rooting of Vetiver in this study after six months was longer than those recorded by Mirniya *et al.,* (2010) for Vetiver as an instrument of erosion control in Golestan after 19 months. The production of plant roots in arid areas is generally greater than their production of biomass and, in wet areas, the production of biomass greater than the production of roots. The results of the present study in a hyperarid area is thus suitable when compared with the results of Miriniya *et al.,* (2010) in a wet area. The results are also consistent with those of Avand *et al.,* (2012). The results of plant height and biomass production in this study was lower than the results of Sanei Dehkordi *et al.,* (2011) for production of Vetiver as animal feed in Khuzestan. This is consistent because the humidity in Sistan plain is much lower than in Khuzestan and Golestan provinces.

The results show that the number of shoots of Vetiver in the hyperarid region of Sistan equaled that of Vetiver reported by Sanei Dehkordi *et al.,* (2011) in Khuzestan province and in other studies (Nippon, 2003). The use of Vetiver to relieve drainage water and wastewater treatment is similar to the results of Barakati *et al.,* (2012) and Akbarzadeh *et al.,* (2013) and the experimental results Binaie in 2014. Other research results on the disposal of infectious wastewater (Truong and Hart, 2001), landfill waste (Percy and Truong (2005) and industrial wastewater Smeal *et al.,* (2003) indicates that Vetiver shows high efficiency in water and soil treatment.

CONCLUSION

The results of this study show optimal performance of the growth variables of *Vetiveria zizonioides* on agricultural land, along river banks and wastewater drainage margins. It was shown to be very effective for stabilization of soil and dust, fodder production and removal of drainage and wastewater treatment. The compatibility of Vetiver with specific climate of Sistan is a major finding of this research. This compatibility has not been previously been reported and provides a wider potential for growth in hyperarid areas.

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