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Original article

Performance evaluation of *Chrysopogon zizanoides* under urban conditions of Kuwait

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ABSTRACT

Plant physiological and morphological attributes should be critically evaluated for selecting any species for landscaping projects. The selection of a species should be based on the evaluation of its adaptability, noninvasiveness, growth potential, and performance under the prevailing local arid conditions for their aesthetic looks, soil stabilization, and afforestation values. *Chrysopogon zizanoides* (Vetiver), is suitable for Kuwait because it can withstand fluctuating temperatures ranging from −14 to 55 °C with unique physical and physiological characteristics. Despite the successful growth performance of Vetiver in landscaping projects mostly in several tropical countries, it has not been utilized and evaluated in the Arabian Gulf region. The objective of the current study was to evaluate the performance of selected ten cultivars of Vetiver (ODV-1, 8, 9, 13, 17, 21, 23, Silent Valley, Urlikal, and Pannimedu) in the deficient soil and environmental conditions of Kuwait in urban landscape at minimal maintenance. It is suggested that based on visual greenery effect and overall growth performance cultivars, Pannimedu, Silent Valley, ODV-13, ODV-8 and ODV-9 can be considered for landscaping projects in Kuwait. To obtain the superior crown volume (which considers height and canopy) cultivar Pannimedu is suggested and to get a bushy growth (considering the number of tillers) cultivar ODV-13 and ODV-8 is found to be suitable.

1. Introduction

Kuwait is an arid country with extremely hot summers with frequent sandstorms, cold winters, low rainfall, sparse vegetation, and highly eroded saline top soil which is deficient in nutrient and organic matter content (Shahid et al., 2003; KISR, 1999). Extreme climatic conditions and water availability are the limiting factors that affect plant growth and development in Kuwait. Drought and salt tolerant plants with minimal nutrient requirement are best suited for use in landscaping and gardening projects in arid countries like Kuwait. As the existing ornamental plant list is inadequate to meet the rising demands of the ever increasing landscape projects, it is necessary to include more native/exotic plants for diversified greenery plans. However, continuous and determined research is essential while introducing exotic plants in various greenery and desert rehabilitation activities. Selection of plants to be included/ introduced in the landscape projects to ensure diversification should be based on the evaluation for their adaptability, non-invasiveness, growth performance, and potential under the prevailing local arid conditions for their aesthetic looks, soil stabilization, and afforestation values. Testing the performance of the selected plants under the prevailing environmental conditions is also necessary to understand the scope and extent of utilization in large projects.

Chrysopogon zizanioides L. Roberty, commonly known as Vetiver was introduced to Kuwait as part of a project conducted by Kuwait Institute for Scientific Research (KISR), and was planted at the Urban Demonstration Garden of KISR in September 2005 (Suleiman and Bhat, 2011). Vetiver is a xerophytic and hydrophytic grass that has several exceptional qualities such as tolerance of hot weather conditions, slope stabilization and rehabilitation, soil and water conservation, reclamation of degraded lands, coastal dune stabilization, erosion control, ecological rehabilitation, tolerance of heavy metals, and growth in polluted soils (Wang, 1991; Laing and Ruppenthal, 1991; Bharad and Bathkal, 1990; Materne and

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Schexnayder, 1992; Yoon, 1993; Truong et al., 1991; Limtong, 2010; Grimshaw, 2006a; Tansamrit, 2008; Roongtanakiat and Chairoj, 2001; Sanguankaeo et al., 2010; Johne et al., 2008; Chomchalow, 2011; Suleiman et al., 2013). The ability of Vetiver to increase soil moisture content, moisture, and nutrient retention, and to reduce soil run off (Grimshaw, 2006a; Juliard, 2006; Truong, 2006) may also prove beneficial especially in the drought conditions of semi-arid regions. Efficiency of Vetiver in removing the heavy metals and other harmful substance from urban landfills and water bodies is an important benefit to Kuwait, where pollution due to oil spillage during war and industrial wastewater are unresolved issues (Xia et al., 2002; Percy and Truong, 2003; Shu, 2003, Liao et al., 2003; Datta et al., 2013; Materechera, 2010; Truong, 2006).

Some of the cultivars of this plant, particularly those that are imported from south India are late or low flowering, sterile or unable to produce seeds (Lavania, 2000; Gupta and Pareek, 1995). The cultivars from south India are sterile and not stoloniforous. The plant is reproduced vegetatively, but do not invade adjacent area as Bermuda grass and couch grass (Grimshaw, 2006b). Thus, concerns over the aggressive growth and invasiveness of this plant and its subsequent negative impacts on the local landscape may not be substantiated (Dafforn, 2000). These attributes make Vetiver a high potential plant to grow under the prevailing environmental conditions of Kuwait. Initial studies on adaptability of Vetiver in Kuwait were conducted by Kurup et al. (2008) focusing on five cultivars from India. Objective of the present study is to evaluate the performance of ten selected Vetiver cultivars in the deficient soil and environmental conditions of Kuwait in an urban setting with minimal tending practices.

2. Materials and methods

2.1. Study site and experimental design

An area of 500 m^2 was selected at KISR's Urban Demonstration Garden (UDG) in Salmiya, Kuwait, considering availability of direct sunlight and proximity to irrigation. The top soil was loosened after clearing the debris. Drip system was used for irrigation. Ten sterile Vetiver cultivars (ODV-1, ODV-8, ODV-9, ODV-13, ODV-17, ODV-21, ODV-23, Silent Valley, Urlikal, and Pannimedu) were procured from international sources and planted on January 30, 2011. A randomized complete block design with five replications of 10 cultivars and three slips per cultivar per replication was used to ascertain the plant's response to the micro-climate in the urban conditions, including their potential for use in greenery enhancement projects. Control plot were not planted with Vetiver. Planting holes of 30 cm width and 30 cm depth were prepared at 1 m × 1 m spacing. The backfill soil mixture was prepared using peat moss, perlite, and sand (1:1:1v/v). A surface mulch of organic material was applied to a depth of 5 cm at the time of planting. The plants were allowed to harden and establish for two months. The physical and chemical properties of soil mix used for refilling of planting holes were analyzed prior to planting. The data on plant height, canopy, basal width and number of tillers were recorded at 0 (March 2011), 150 (August 2011), 300 (January 2012) and 480 days (July 2012) after establishment. The first recorded data at the end of the establishment period were considered as the initial data.

2.2. Data collection and analysis

Physical and chemical properties of soil, water, and planting medium were analyzed at Soil Chemistry Laboratory and Central Analytical Laboratory of KISR as per procedures prescribed by USDA (1996) and APHA (2005) (Table 1). Composite soil samples were collected before the initiation of the experiment and at the end of the trials. To analyze the organic matter content, the composite soil samples were collected at 30, 60 and 90 depth from the Vetiver planted area and at 30 cm depth in the controls area. The parameters analyzed for soil and planting medium were bulk density, porosity, saturation percentage pH, electrical conductivity (EC), calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), chloride (Cl), sulphate (SO_4), nitrate (NO_3), carbonate (CO_3), and bicarbonates (HCO3). Organic carbon was determined by the Walkley and Black (1934) and expressed in percentage. Organic matter was determined by multiplying the organic carbon value with 1.7 and is expressed as a percentage. Percentage increase in organic matter content at the end of the experimental period was calculated using the following formula.

Table 1
Reference methods used for soil and water analysis.

Sl. No.	109537538100Test description analysis/preparation	Reference method
1	pH	8C1b (USDA, 1996) pg.411
2	Electrical conductivity	8A3a (USDA, 1996) pg.407
3	Calcium	6N1a (USDA, 1996) pg. 638
4	Magnesium	6O1a (USDA, 1996) pg.645
5	Sodium	6P1a (USDA, 1996) pg.650
6	Potassium	6Q1a (USDA, 1996) pg.652
7	Carbonate and bicarbonate	6I l (USDA, 1996) pg.283
8	Chloride	4500-Cl-D (APHA, 2005)
9	Nitrate	ISO 7890-1-1986 (instrument manual)
10	Sulphate	EPA 375.4 (instrument manual)
11	Bulk density	4A3a (USDA, 1996)
12	Porosity	USDA Hand book No.60,6:40
13	Saturation percentage	USDA Hand book No.60,6: 27a

$$\textit{Percentage increase in organic matter} = \frac{\textit{Final value} - \textit{Initial value}}{\textit{Initial value}} * 100$$

Soil was dried overnight at 105 °C, and the moisture content was determined at dry weight basis and expressed in percentage. The parameters analyzed in water samples were pH, EC, total dissolvable salts (TDS), Ca^{2+}, K^-, Mg^{2+}, Na^{2+}, boron (B), SO_4^{2-}, CO_3^-, HCO_3^-, NO_3^-, and Cl^-. Data on plant height, canopy, basal width and number of tillers were recorded at 0, 150, 300 and 480 days after planting (DAP). Crown volume was calculated from the recorded plant height and canopy using the following formula (Thalen, 1979):

$$\textit{Crown Volume} = \frac{1}{6}\pi \times D1 \times D2 \times h$$

where D1 is the horizontal diameter of the crown, D2 is the vertical diameter of the crown, h is the height of the plant, and π equals 3.14. Relative growth (Suleiman et al., 2013) in plant height, canopy, and number of tillers was calculated as follows:

$$\textit{Relative Growth}\ (\%) = \frac{\textit{Final value} - \textit{Initial value}}{\textit{Initial value}} * 100$$

Visual greenery effect ratings for the selected cultivars (Frank et al., 2013) were recorded in terms of Grades 1 to 3 (with 3 being the highest). Data on temperature, relative humidity, and rainfall were recorded from the Weather Station at Salmiya.

The collected data were analyzed using one-way analysis of variance (ANOVA) and Duncan's Multiple Range test to ascertain the significant differences among cultivars (Little and Hills, 1978). The relative growth in the various plant growth parameters