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Performance of Selected Ornamental Plants under Flood and Drought Conditions

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ABSTRACT

Plants would be more vulnerable to drought and flooding stress or a cycled water environmental change, which occur more frequently under climatic change conditions. Under these circumstances it is vital to identify plants which could tolerate both extremes. Hence an experiment was conducted to identify the performance of *Dracaena sanderiana* White, *Polyscias balfouriana* Marginata and *Crossandra infundibuliformis* under flood and drought conditions. Plants were subjected to constant water level (1 cm) above the media for 18, 22, 26, and 30 days respectively as treatments for flood tolerance experiment and another set of plants were subjected to field capacity level and each variety were subjected to drought stress for durations of 27, 31, 35, and 39 days respectively for drought tolerance experiment. After respective treatments tolerance to stress and growth parameters were measured. The data analysis were performed based on ANOVA to find out the best treatment. Based on survival percentage, flood tolerance in terms of resistance for wilting and better visual appearance, and growth performances, *Dracaena* can be recommended as the best plant to survive under flood conditions followed by *Polyscias*. Survival rates of 100% and 91% were recorded in respective species 30 days after treatment (DAT). In drought tolerance experiment, *Polyscias* followed by *Dracaena* can be recommended as 100% survival rates were recorded 35 DAT. However, in *Dracaena* drought condition has a negative effect on visual quality. Compared to other species, the performance of *Crossandra* is poor under flood and drought conditions.

KEYWORDS: Climate change, Drought, Flood, Ornamental plants, Rainwater gardens

INTRODUCTION

Global climate change has been witnessed over the past decades and is anticipated to continue in the future (IPCC, 2007). Further, rainfall patterns cannot be foretold with much assurance and therefore, extreme weather conditions are becoming common. With recent climate change, extremes in meteorological conditions are forecasted and observed to increase globally (Solomon *et al.*, 2007). More prolonged dry periods will alternate with more intensive rainfall events, both within and between years, which will change soil moisture dynamics (Fay *et al.*, 2008).

Floods are common in Sri Lanka than the other natural disasters. Heavy rainfall and runoff of the large volume of water from the catchment areas of rivers, deforestation, improper land use and the absence of scientific soil conservation practices could be identified as the major factors for floods (Anon, 2016). Urbanization with the insufficient infrastructure facilities triggers the urban flash floods together with global phenomena like climate change, which increased rainfall intensities (Anon, 2009).

Flash floods are caused by intense storms dropping large amount of water within a brief time span (Surenthirakumaran, 2009). Flood stressed caused by intense storms dropping large trees exhibit a wide range of symptoms including leaf chlorosis, defoliation, reduced leaf size, and shoot growth and die back (Iles and Gleason, 1994). As a solution to flooding in managed landscapes, designers have developed a flood tolerant design concept known as rain gardens. Rain garden is a simple storm water management system designed to treat and minimized runoff from hard surface (Coyman and Silaphone, 2011). To implement rain water garden designs flood tolerant plants should be selected.

Drought is one of the most significant hazard in Sri Lanka in terms of people affected and relief provided. Drought occurs in the South-eastern, North central and North-western areas of Sri Lanka due to low rainfall during monsoons. Large parts of the island are drought-prone from February to April and on to September if the subsidiary rainy season from May to June is dry (Anon, 2009).

Selecting trees that use water efficiently without the need for frequent watering or irrigation is one way to make landscape more resistant to droughts. With impending water shortages in many urban areas leading to prohibitions of irrigation or watering, planting trees that are more tolerant to drought conditions is the best long-term solution to maintain landscapes (Kim, 1999).

Drought stressed trees exhibit a wide range of symptoms including wilting, marginal leaf scorch and loss of some foliage in an effort to preserve energy. In the long term, after severe drought, twigs and branches may die back (Fair, 2001). As a solution to drought conditions in managed landscapes, designers have developed a drought tolerant design concept known as xeriscape landscaping. It is, specifically for areas that are susceptible to drought or for properties where water conservation is practiced (Anon, 2016).

Therefore, this study was conducted with the objective of assessing the flood and drought tolerance of selected ornamental plants in view of promoting them in sustainable landscape designs in Sri Lanka.

MATERIALS AND METHODS

Experimental Site

Study was conducted in a plant house at the Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, from January to May 2016. During the study period, the average temperature, light intensity and relative humidity in the plant house was 32 °C, 364 lux and 80% respectively.

Planting Material

Softwood cuttings of *Dracaena sanderiana* White, *Polyscias balfouriana* Marginata and *Crossandra infundibuliformis* (15 cm) were planted in a sand bed inside a propagator in a net house (70% shade). After four months rooted plants were transplanted into black polythene bags (20×15 cm, gauge 300). The pots were filled with media (top soil: compost: sand 1:2:1), up to 17 cm height and placed in the plant house for another week before apply respective treatments.

Layout of the Experiment

Both flood and drought experiments consisted with four treatments. Each treatment consists with 32 pots hence altogether 128 pots were arranged in complete randomized design (CRD).

Performance of Plants under Induced Flood Condition

Initially plants were irrigated up to the field capacity and thereafter a constant water level (1 cm) above the media was maintained for 18, 22, 26, and 30 days respectively. The plants growing under normal non-flooded conditions served as the control. Data were collected one week after the respective treatments allowing plants to recover. The details of the data are given under the section data collection.

Performance of Plants under Induced Drought Conditions

Plants were subjected to field capacity level as described above and thereafter each variety were subjected to drought stress for different durations of 27, 31, 35, and 39 days respectively. The control experiment was maintained under normal growth conditions. Plants were re-watered after the respective drought stress of different durations and data were collected as described below after one week recovery period.

Data Collection

Flood and Drought Tolerance of Plants

Individual plants were scored for tolerance using a modified scale as described by Yeboah (2008).

Where,
1=dead plant
2=more than 50% leaves wilt
3=less than 50% leaves wilt
4=green plants with no signs of stress

Flood/drought tolerance score of individual plants in terms of colour changes of leaves were determined using a scale given below.
3-100% natural colour
2-more than 50% of natural colour
1-less than 50% of natural colour

Growth Parameters

Plants were uprooted and dry weight of shoots, leaves and roots were measured (oven dried at 105 °C for 24 hours).

Statistical Analysis

The data were subjected to ANOVA using Minitab version 15 statistical package.

RESULTS AND DISCUSSION

Flood Tolerance

Survival Percentage

The highest survival percentage was recorded in *Dracaena sanderiana* White (100%) followed by *Polyscias balfouriana* Marginata (91%) 30 days after treatment (DAT). In *Crossandra infundibuliformis* survival percentage was drastically reduced 18 DAT (Figure 1). Hence under flooded conditions, *Dracaena* and *Polyscias* can survive longer than *Crossandra infundibuliformis.*

Resistance for Wilting

The highest flood tolerance in terms of resistance for wilting was observed in *Dracaena sanderiana* White (Figure 2). The lowest was observed in *Crossandra infundibuliformis* and it initiate to wilt 6 DAT.

Visual Appearance

Visual appearance in terms of colour change is more or less constant in *Dracaena* (Figure 3). However, it was drastically reduced in *Crossandra* 9 DAT. In *Polyscias*, it initiated to reduce 9 DAT but it was started to recover again from 12 DAT due to the formation of new leaves. In all the three species, colour changes were observed in mature leaves.

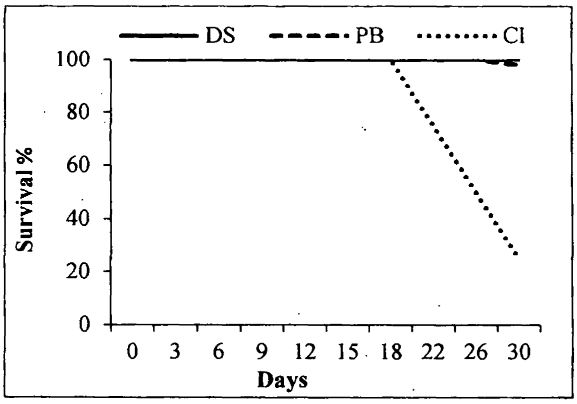

Figure 1. Survival percentage of plants under flood condition. *DS- Dracaena sanderiana; PB-Polyscias balfouriana; CI-Crossandra infundibuliformis*

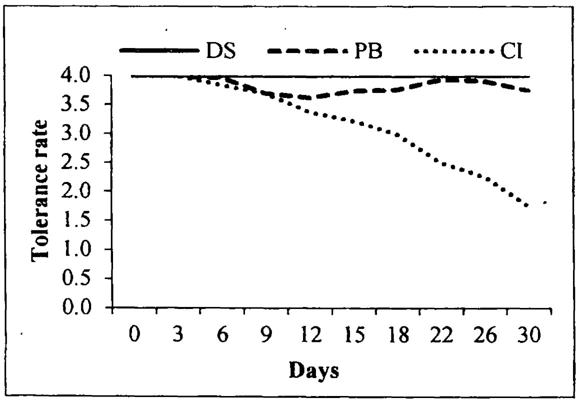

Figure 2. Tolerance of plants to flood conditions measured in 1 to 4 scale. *DS-Dracaena sanderiana; PB-Polyscias balfouriana; CI-Crossandra infundibuliformis*

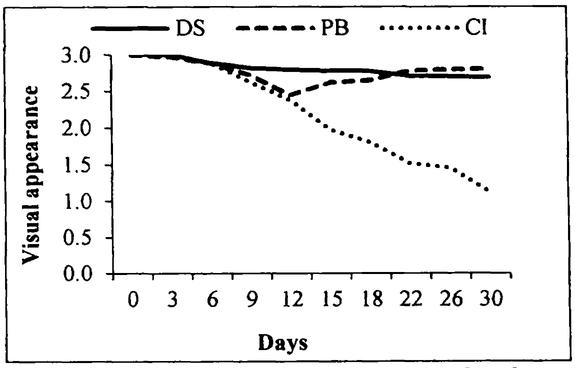

Figure 3. Visual appearance of plants measured in 1 to 3 scale. *DS- Dracaena sanderiana; PB-Polyscias balfouriana; CI-Crossandra infundibuliformis*

Growth Performance

Root dry weights were significantly high throughout the study period in *Dracaena* (Table 1). In *Polyscias*, root dry weight was significantly reduced in 30 DAT compared to other treatments. While in *Crossandra* it was significantly low from 22 DAT.

Shoot dry weights and leaf dry weights were significantly high in *Dracaena* throughout the study period (Table 1). In *Polyscias*, both parameters were significantly high in 26 DAT. Hence there was no any significant difference in shoot dry weight and leaf dry weight between *Dracaena* and *Polyscias* after 26 DAT. In *Crossandra,* it was significantly low from 22 DAT.

Based on survival percentage, flood tolerance (in terms of resistance for wilting and better visual appearance in terms of colour change) and growth performances, *Dracaena* can be recommended as the best plant to survive under flooded conditions. According to the present study, it survived up to 30 days under flood conditions. This was followed by *Polyscias balfouriana* and *Crossandra.*

Table 1. Mean growth parameters of plants under flood condition

Treatment	Plant	Root dry weight (g)	Shoot dry weight (g)	Leaf dry weight (g)
T_1	*Dracaena*	$0.46^a \pm 0.12$	$1.37^a \pm 0.24$	$1.82^a \pm 0.22$
(18 DAT)	*Polyscias*	$0.08^b \pm 0.04$	$0.61^c \pm 0.21$	$0.49^b \pm 0.34$
	Crossandra	$0.11^b \pm 0.10$	$0.24^a \pm 0.07$	$0.19^b \pm 0.09$
T_2	*Dracaena*	$0.46^a \pm 0.16$	$1.38^a \pm 0.26$	$1.69^a \pm 0.19$
(22 DAT)	*Polyscias*	$0.08^b \pm 0.08$	$0.68^b \pm 0.31$	$0.37^c \pm 0.46$
	Crossandra	$0.03^c \pm 0.05$	$0.16^b \pm 0.20$	$0.17^b \pm 0.20$
T_3	*Dracaena*	$0.37^a \pm 0.07$	$1.25^a \pm 0.23$	$1.56^a \pm 0.34$
(26 DAT)	*Polyscias*	$0.06^b \pm 0.10$	$1.26^a \pm 0.56$	$0.67^a \pm 0.59$
	Crossandra	$0.03^c \pm 0.03$	$0.18^b \pm 0.23$	$0.17^b \pm 0.19$
T_4	*Dracaena*	$0.46^a \pm 0.15$	$1.26^a \pm 0.34$	$1.71^a \pm 0.41$
(30 DAT)	*Polyscias*	$0.03^c \pm 0.07$	$1.41^a \pm 0.58$	$0.96^a \pm 0.58$
	Crossandra	$0.02^c \pm 0.14$	$0.27^a \pm 0.56$	$0.11^b \pm 0.49$

Mean with same superscript letters are not significantly different at 0.05 level; DAT-Days after treatments

Drought Tolerance

Survival Percentage

The highest survival percentage was recorded in *Dracaena* and *Polyscias* (100%) 39 DAT followed by *Crossandra* (74%) (Figure 4).

Resistance for Wilting

The highest drought tolerance in terms of resistance for wilting was observed in both *Dracaena* and *Polyscias* (Figure 5). The lowest was observed in *Crossandra* and it initiate to wilt 9 DAT and it continued.

Visual Appearance

Visual appearance in terms of colour change reduced with time in all the three species (Figure 6). However, it was drastically reduced in *Dracaena* 15 DAT due to the formation of brown colour necrotic spots. In *Crossandra* a sharp reduction was observed 24 DAT while visual appearance was least affected in *Polyscias.*

Growth Performance

Under drought conditions, root dry weights were significantly high throughout the study period in all the three species (Table 2).

Shoot dry weights were also significantly high throughout the study period in *Dracaena.* However, in *Polyscias* shoot dry weights were significantly low up to 31 DAT but it recovered thereafter. In *Crossandra* it was significantly low.

Leaf dry weights were significantly high in *Dracaena* throughout the study period while in other two species it was significantly low.

Compared to other two species, lowest survival rates and drought tolerance (in terms of resistance for wilting) were recorded in *Crossandra.* While in other two species, survival rates were high. However, visual appearance in terms of colour change was best in *Polyscias* followed by *Crossandra.* In terms of the growth performance, *Dracaena* is the best.

In overall performance, *Polyscias* can be recommended over others due to higher survival rates and visual quality. *Polyscias* has the highest stem diameter compared to other species. Stem diameter is correlated directly with the capacity for transporting water and carbohydrate (Stuefer, 1998). In landscaping visual quality plays an important role as it directly associated with aesthetics. However, in xeriscape landscape, temporary loss of quality is accepted hence both *Polyscias* and *Dracaena* could be promoted as drought resistant plants in landscaping.

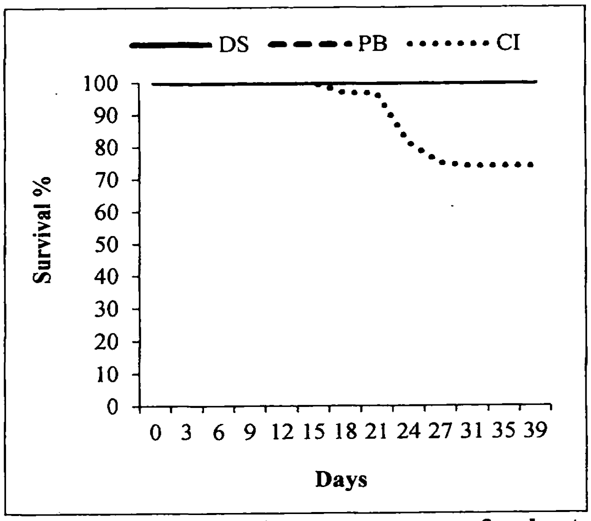

Figure 4. Survival percentage of plants under drought conditions. *DS- Dracaena sanderiana* White; *PB-Polyscias balfouriana* Marginata; *CI-Crossandra infundibuliformis*

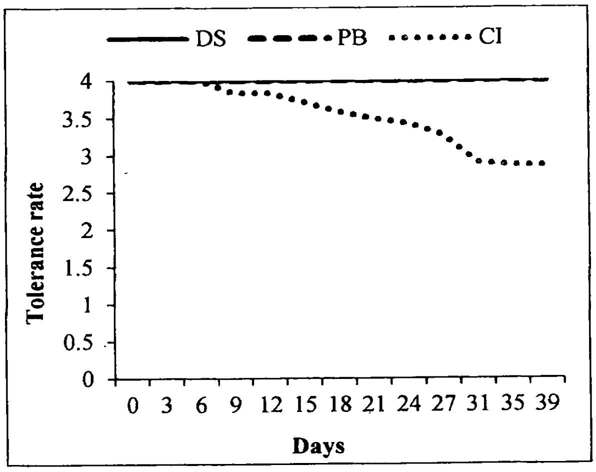

Figure 5. Tolerance of plants to drought conditions measured in 1 to 4 scale. *DS- Dracaena sanderiana* White; *PB-Polyscias balfouriana* Marginata; *CI-Crossandra infundibuliformis*

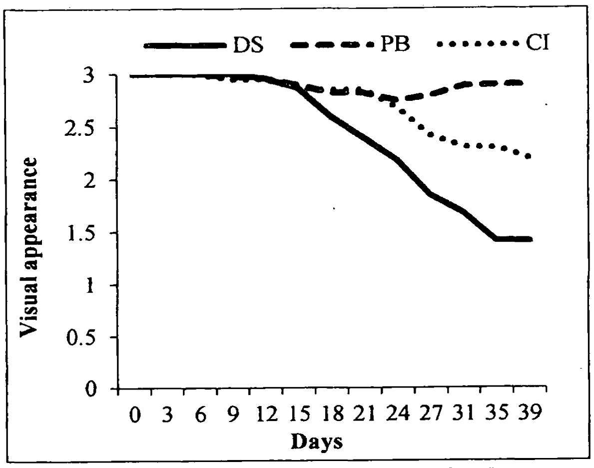

Figure 6. Visual appearance of plants to Drought conditions measured in 1 to 3 scale. *DS- Dracaena sanderiana* White; *PB-Polyscias balfouriana* Marginata; *CI-Crossandra infundibuliformis*

Table 2. Mean growth parameters of plants under drought conditions

Treatment	Plant	Root dry weight (g)	Shoot dry weight (g)	Leaf dry weight (g)
T_1	*Dracaena*	$0.41^a \pm 0.19$	$1.08^a \pm 0.31$	$1.24^a \pm 0.31$
(27 DAT)	*Polyscias*	$0.15^a \pm 0.1$	$0.90^b \pm 0.39$	$0.60^c \pm 0.38$
	Crossandra	$0.11^a \pm 0.06$	$0.45^b \pm 0.14$	$0.60^b \pm 0.01$
T_2	*Dracaena*	$0.35^a \pm 0.92$	$1.13^a \pm 0.20$	$1.54^a \pm 0.20$
(31 DAT)	*Polyscias*	$0.14^a \pm 0.10$	$0.82^b \pm 0.50$	$0.72^c \pm 0.50$
	Crossandra	$0.17^a \pm 0.26$	$0.25^c \pm 0.30$	$0.10^c \pm 0.10$
T_3	*Dracaena*	$0.44^a \pm 0.10$	$1.23^a \pm 0.30$	$1.36^a \pm 0.40$
(35 DAT)	*Polyscias*	$0.83^a \pm 0.10$	$1.45^a \pm 0.30$	$1.16^c \pm 0.40$
	Crossandra	$0.10^a \pm 0.10$	$0.47^b \pm 0.50$	$0.20^c \pm 0.20$
T_4	*Dracaena*	$0.41^a \pm 0.13$	$1.31^a \pm 0.39$	$1.49^a \pm 0.46$
(39 DAT)	*Polyscias*	$0.34^a \pm 0.14$	$1.71^a \pm 0.41$	$1.60^b \pm 0.57$
	Crossandra	$0.17^a \pm 0.18$	$0.46^b \pm 0.36$	$0.27^c \pm 0.26$

Mean with same superscript letters are not significantly different at 0.05 level; DAT-Days after treatment

CONCLUSIONS

Based on survival percentage, flood tolerance and growth performances, *Dracaena* can be recommended as the best plant to survive under flooded conditions followed by *Polyscias*. *Dracaena* could survive up to 30 days under flood conditions. Under drought conditions *Dracaena* and *Polyscias* both can be recommended due to the higher survival rates and drought tolerance. However, in *Dracaena* drought conditions has a negative effect on visual quality. Compared to other species, the performance of *Crossandra* is poor under flood and drought conditions.

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