European Journal of Scientific Research
ISSN 1450-216X Vol.14 No.2 (2006), pp. 173-179

http://www.eurojournals.com/ejsr.htm

Screening of Plants for Drought Tolerance

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Abstract

Drought tolerance is a feature of some crop plants which can survive a moderate period of limited moisture. In this study, plants were subjected to induced water stress to quantify their irrigation requirements thus conserving irrigation water usage for future recommendation on their utilization. Ten plant species subjected to the present study included *Acacia biflora, Acalypha wilkesiana, Allamanda cathartica, Calliandra haematocephala, Clerodendron thomsonae, Duranta goldiana, Ficus pumila, Peltophorus pterocarpus, Thespesia populnea* and *Tephrosia haussknechtii*. Following their establishment, irrigation stress was administered by irrigating the plants at predetermined soil moisture depletion levels (moisture percentage at <2, 2-4 and 4-6). *Allamanda cathartica, Clerodendrum thomsoniae and Duranta goldiana* appeared to tolerate water stress better than others. *Acacia biflora, Acalypha wilkesiana and Tephrosia haussknechtii* were severely affected, while, *Peltophorus pterocarpus* and *Thespesia populnea* were moderately affected by water stress condition.

Introduction

World population is increasing at an alarming rate and is expected to reach about six billion by the end of the year 2050. On the other hand, food productivity is decreasing due to the effect of various abiotic stresses, which adversely effect plant's growth and productivity (Mahajan and Tuteja, 2005). Stresses caused by abiotic conditions such as temperature extremes (freezing, cold and heat), water availability (drought and ion excess) and ion toxicity (salinity and heavy metals) have been difficult to dissect because defense responses to abiotic factors require regulatory changes to the activation of multiple genes and pathways (Bohnert et al., 2006). With the increase in urbanization and industrialization, large quantities of fresh water supplies will be diverted from agriculture to meet the growing water demand in the municipal and industrial sectors (Hamadi et al., 1995 and Correia., 1999). Water scarcity in the arid zones with high rates of evaporation, appears as one of the main factors limiting agricultural development. As increased irrigation is not a visible answer to the problem, an economically and environmentally desirable solution is to introduce new varieties with decreased sensitivity to water deficits.

A high intrinsic water use efficiency and ability to maintain some capacity for photosynthesis under severe water stress undoubtedly contribute to the survival of *Phragmites australis* under dry conditions (Pagter et al., 2005). According to Sehwinning et al., 2005, drought effects on plant water status were qualitatively similar among species, despite morphological differences. Summer drought affected the water status of all species more negatively than winter drought Plants are classified as drought sensitive or tolerant plants. Forti et al., 2006 stressed the importance of longevity of the plants, under arid conditions, in combination with good shape, vigor and good health particularly for projects in which the economic benefit is largely indirect ie. soil conservation and landscaping. Drought tolerant plants maintain their turgor at low water potential by increasing the number of solute molecules in the cell (Radin, 1983; MacNeilet al., 1999; Bray et al., 2000).

Screening of plants for drought stress tolerance is important for sustainable utilization of available plant resources, land and water resources in landscape development. In view of these facts, the following study on drought tolerance of selected introduced ornamental plants was conducted in the greenhouse at Kuwait Institute for Scientific Research (KISR).

Methodology

Containerized plants of species listed in the Table 1 were used during the study. The test plants were transplanted in 15 gallon plastic containers filled with agricultural soil. The soil sample was analyzed prior to planting. Test plants were irrigated to field capacity until they were established in these containers. Following their establishment, irrigation stress was administered by irrigating the plants at predetermined soil moisture depletion levels (moisture percentage at <2, 2-4 and 4-6). Westminster plant light and moisture meter was used to measure the soil moisture, for their ease of use. Freshwater was used for this experiment. The effect of water stress on vegetative growth and visual qualities were assessed. The study was conducted for a period of fourteen months.

A complete randomized block design with three treatments and five replications per treatment was used upon establishment of the trials. Observations on survival rate, plant height and flowering were recorded at monthly intervals. Foliar spray of 5% potassium nitrate was given to the test plants at bi-weekly intervals. Plant protection measures were conducted regularly to control the pest and disease infestations.

Results and Discussion

The effects of water stress on the survival percentage of different plant species are presented in Table 1. Plant survival in *Acacia biflora* and *Tephrosia haussknechtii* was zero in all water stress treatments. In contrast, survival of *Allamanda cathartica* and *Thespesia populnea* was not affected by the induced water stress. The remaining species were marginally affected by drought treatment (Fig 1).

Fig. 1: Survival percentage of experimental plants under drought trial at 390 days after planting.

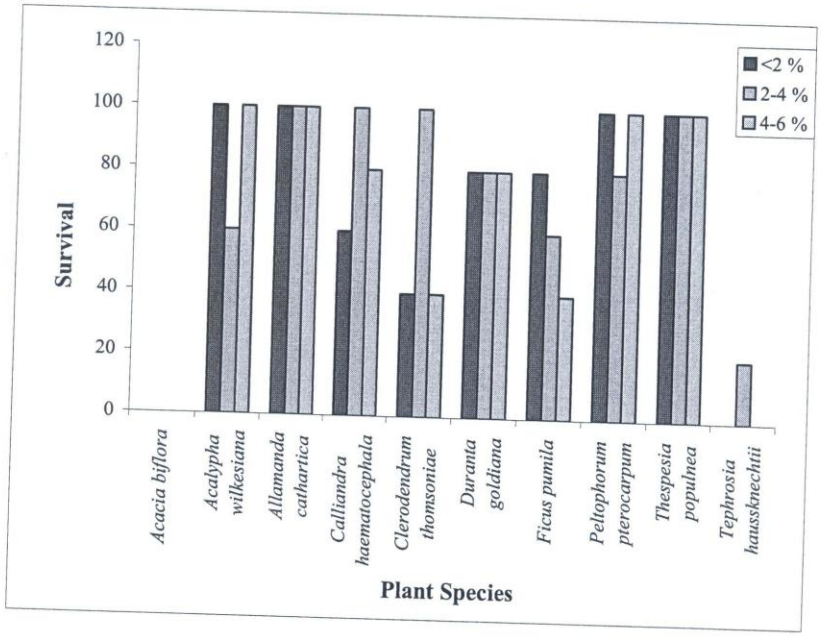


Table 1: Periodic Survival of Plant Species under Drought Trial

Plant Species	Moisture (%)	Plant Survival (%)						
		60 DAP	120 DAP	180 DAP	240 DAP	300 DAP	360 DAP	390 DAP
Acalypha wilkesiana	<2	100	100	100	100	100	100	100
	2-4	100	100	80	80	60	60	60
	4-6	100	100	100	100	100	100	100
Acacia biflora	<2	100	100	100	0	0	0	0
	2-4	100	100	60	20	0	0	0
	4-6	100	100	100	40	0	0	0
Allamanda catharicta	<2	100	100	100	100	100	100	100
	2-4	100	100	100	100	100	100	100
	4-6	100	100	100	100	100	100	100
Calliandra haematocephala	<2	100	100	100	100	60	60	60
	2-4	100	100	100	100	100	100	100
	4-6	100	100	100	100	80	80	80
Clerodendron thomsonae	<2	100	100	100	100	100	40	40
	2-4	100	100	100	100	100	100	100
	4-6	100	100	100	100	80	60	40
Duranta goldiana	<2	100	100	100	100	100	80	80
	2-4	100	100	100	100	100	100	80
	4-6	100	100	100	100	80	80	80
Ficus pumila	<2	100	100	100	100	100	80	80
	2-4	100	100	100	60	60	60	60
	4-6	80	80	80	80	80	80	40
Peltophorus pterocarpus	<2	100	100	100	100	100	100	100
	2-4	100	100	100	100	80	80	80
	4-6	100	100	100	100	100	100	100
Thespesia populnea	<2	100	100	100	100	100	100	100
	2-4	100	100	100	100	100	100	100
	4-6	100	100	100	100	100	100	100
Tephrosia haussknechtii	<2	100	100	80	60	40	20	0
	2-4	100	100	100	100	80	20	20
	4-6	100	100	100	80	80	20	0

DAP= Days after Planting

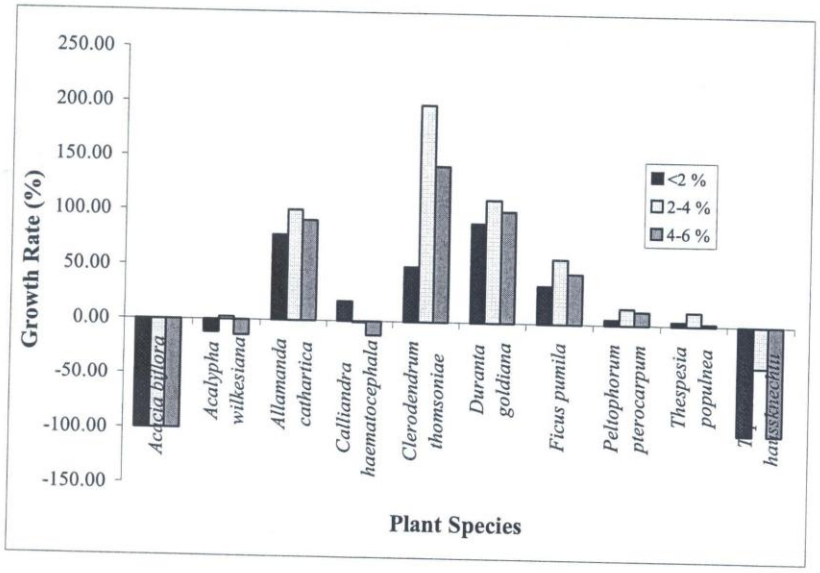
Table 2: The Height of the Experimental Plants under Drought Trial

Plant Species	Moisture (%)	Plant Height (cm)								Growth Rate (%)
		Initial	60 DAP	120 DAP	180 DAP	240 DAP	300 DAP	360 DAP	390 DAP	
Acalypha wilkesiana	<2	56.60	54.80	47.60	41.60	44.00	48.80	48.60	49.80	-12.01
	2-4	40.60	50.40	30.60	40.25	36.50	39.67	40.33	41.67	2.63
	4-6	58.60	60.40	49.00	45.20	43.00	47.40	47.80	50.40	-13.99
Acacia biflora	<2	38.80	43.40	35.00	34.80	Dead	Dead	0.00	0.00	-100.00
	2-4	37.60	41.40	33.00	43.00	72.00	Dead	0.00	0.00	-100.00
	4-6	51.20	53.40	50.80	50.60	66.00	Dead	0.00	0.00	-100.00
Allamanda cathartica	<2	105.40	113.00	118.40	104.00	123.40	161.60	175.20	187.80	78.18
	2-4	109.80	121.00	114.20	113.80	136.20	168.60	203.20	220.60	100.91
	4-6	106.40	107.40	105.20	108.60	160.80	150.80	177.60	203.80	91.54
Calliandra haematocephala	<2	106.40	110.60	110.00	107.80	119.20	160.33	126.00	125.67	18.11
	2-4	93.20	95.20	96.40	87.60	93.60	92.20	95.60	92.20	-1.07
	4-6	100.60	110.20	109.20	105.80	122.60	119.25	102.00	87.75	-12.77
Clerodendron thomsonae	<2	28.40	28.20	29.00	24.60	34.40	36.00	41.00	42.67	50.23
	2-4	34.60	42.40	47.00	44.80	49.60	103.40	107.60	103.40	198.84
	4-6	34.20	43.40	39.40	37.00	42.40	59.75	65.33	83.00	142.69
Duranta goldiana	<2	31.20	35.60	36.00	33.60	41.00	54.00	58.75	59.50	90.71
	2-4	32.60	42.80	46.20	54.20	61.00	69.80	69.20	69.25	112.42
	4-6	31.60	35.40	37.20	40.40	53.60	63.50	64.00	63.75	101.74
Ficus pumila	<2	28.20	41.20	37.20	50.60	51.60	41.00	45.25	38.00	34.75
	2-4	25.20	32.40	34.00	45.20	39.67	51.33	45.67	40.00	58.73
	4-6	16.80	23.25	23.50	29.50	41.00	45.25	26.25	24.50	45.83
Peltophorus pterocarpus	<2	116.00	124.20	117.40	99.40	113.60	119.00	120.40	121.80	5.00
	2-4	152.80	155.80	147.40	129.00	150.60	170.25	174.75	175.75	15.02
	4-6	139.80	143.00	139.60	115.20	149.80	152.80	156.40	157.00	12.30
Thespesia populnea	<2	116.40	117.20	111.60	109.80	109.80	119.60	120.20	120.60	3.61
	2-4	134.40	138.00	129.80	127.20	137.60	144.80	153.20	151.00	12.35
	4-6	140.60	142.60	137.00	133.80	135.00	144.60	142.40	143.40	1.99
Tephrosia haussknechtii	<2	32.20	35.20	31.40	32.25	38.33	32.00	30.00	0.00	-100.00
	2-4	30.60	34.20	33.20	37.40	41.00	35.75	21.00	19.00	-37.91
	4-6	27.60	30.60	28.40	28.60	34.50	31.00	42.00	0.00	-100.00

DAP= Days after Planting

Plant height and the growth rate of the experimental plants under drought stress are presented in Table 2. The growth rate ranged from -100.00 to 90.71, -100.00 to 198.84 and -100.00 to 101.74, respectively in severe, moderate and no water stress treatments (Fig. 2). Results indicated that *Allamanda cathartica, Clerodendrum thomsoniae* and *Duranta goldiana* appeared to tolerate water stress better than others. *Acacia biflora*, *Acalypha wilkesiana* and *Tephrosia haussknechtii* were severely affected, whereas *Peltophorum pterocarpum* and *Thespesia populnea* were moderately affected by water stress. In contrast, growth rate in *Calliandra haematocephala* decreased with increase in the amount of water added.

Fig. 2. Growth rate of experimental plants under drought trial at 390 days after planting.



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