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Evaluation of shrub performance under arid conditions

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Abstract

The climate of Kuwait is characterized by very hot, dry summers and cool rainy winters. Although a large number of ornamental plants had proved to endure such environmental conditions, Kuwait is dependent on a limited species previously introduced to the country. A greater diversification is required to increase the plant list in developing an urban demonstration garden. Developing plants that have all attractive characteristics during all four seasons help gardeners reach their goal of a well-planned landscape. Careful plant selection is the key first step in developing a balanced and self perpetuating landscape. The purpose of this study was to test and evaluate a list of ornamental shrubs that had not been previously tested, for their suitability to Kuwait. Thus this study was conducted on twenty six shrub species in the inland site and coastal site. These plants were obtained from Australia and India. The shrubs were tested for their suitability to withstand the adverse climatic conditions of Kuwait. It was observed that in summer *Bambusa vulgaris* Aureo-variegata, *Hakea laurina*, *Calliandra haematocephala* and *Justicia aurea* were not able to survive the intense heat during the months of July and August. Some shrubs like *Cestrum diurnum*, *Eucalyptus websteriana*, *Hamelia patens*, *Holmskioldia sanguinea* etc. were moderately sensitive to the heat and *Acacia sclerophylla*, *Acacia wilhelmina*, *Hibiscus rosasinensis* variegate, *Banksia ashbyi*, *Gossypium sturtianum*, *Callistemon viminalis* 'Captain Cook, *Nyctanthes arboretum* and *Russelia equisetiformis* were found to have excellent growth in summer. The survival percentages of plants like *Geijera parviflora*, *Gossypium stuartianum*, *Cestrum diurnum*, *Holmskioldia sanguinea, Brachychiton rupestris*, *Nyctanthes arboretum* and *Euphorbia characias* were hundred percent.

Key words: Ornamental plants, diversification, gardeners, landscape, shrub, inland site, coastal site, intense heat.

Introduction

With the rapid development of the urban and suburban areas in Kuwait, including residential and commercial areas, the demand for greenery and beautification is increasing massively. This increase demands vast amounts of diversified plant materials. For proper implementation of the various landscape projects, including public parks, streetscapes and home gardens, an efficient ornamental plant list should be developed. This can only be accomplished by plant introduction and screening under the prevailing weather conditions of Kuwait. The success of a site-suitable landscaping trend depends on appropriate plant selection [6-8].

The development of a greenery plan for Kuwait requires intensive water management. This goal can be achieved through manpower training in landscape development, selection of plants tolerant to arid environments and usage of appropriate irrigation systems [9]. Low water use plantings may enhance water conservation in dry landscapes. Therefore, the demand for landscape plantings that has a low water requirement is increasing. In arid landscapes, where nutrients are concentrated in biophilic profiles under patches vegetated with either shrubs or perennial grasses [1], the presence of these vegetated patches may moderate effects of wind and water on movement of plant nutrients, organic matter and litter around landscape [2, 10].

Residential landscape constitutes a significant portion of the urban environment. With the increasing mobility of the society, many people come to reside in environments with unfamiliar plant communities and environmental conditions [4]. Promotion of ornamental plants will improve the quality of the environment and the increase in the diversity of plants. For the above mentioned reasons this study was conducted in two locations namely, inland and coastal site.

One of the main components of the landscape is the shrubs. Shrubs range from approximately 3 to 10 feet height, are defined as woody plants, and are multi-stemmed and low branching. Low growing shrubs can be arranged to divide space at ground level, a physical separation rather than a visual one. Larger shrubs growing above eye level will define space. Shrubs can be grown in their natural form or on the other hand may be clipped or pruned into shape [3]. Selecting plants that have attractive characteristics during all four seasons helps gardeners reach their goal of a well planned landscape [5]. Some plants have several attributes that exhibit ornamental qualities during each season of the year. A properly planted tree or shrub will be tolerant of adverse conditions and require much less management than planted incorrectly. The plant should be specifically appropriate to the site or the site should be amended to specifically to fit the plant. In this study twenty six species of ornamental shrubs that had not been previously tested in Kuwait, were evaluated for their adaptability

to extreme conditions and their visual impact on the greenery. These plants were tested in two sites namely, the inland and coastal site. The inland site selected was away from the sea and the coastal site was adjacent to the sea.

Methodology

A total of 26 plant species listed in Table 1 were selected for their performance in the extreme climates of Kuwait. These plant species were procured from those parts of Australia and India, where the climatic conditions match with those in Kuwait. These plants were allowed to harden in the greenhouse. Before the start of the experiment the site was developed. The land was cleared of all the weeds trash, rocks, dirt clods and other debris. The soil was analyzed for the presence of nutrients. Chemical analysis of water was also done prior to planting. In the planting holes in both site 30 cm of the top layer was back filled with agricultural soil and peat moss. The sites were fine graded and leveled. Soil was disinfected and weed treated. Soil was irrigated before planting to leach salts from the soil and was followed by a drying period of two days. The hardened plants were then transplanted in the field and a complete randomized block design was used. The transplanted plants were medium in size and had a healthy green appearance.

Table 1. Survival percentages of experimental shrubs in the inland and coastal site.

Plant species	Survival (%)	
	Inland site	Coastal site
Eucalyptus torwood	80	100
Acacia sclerophylla	60	100
Acacia wilhelmina	60	100
Geijera parviflora	100	100
Hibiscus rosasinensis variegata	0	100
Bambusa vulgaris Aureovariegata	40	80
Banksia ashbyi	40	100
Gossypium sturtianum	100	100
Calliandra haematocephala	20	60
Callistemon viminalis 'Captain Cook'	0	100
Cestrum diurnum	100	100
Eucalyptus nutans	100	60
Eucalyptus websteriana	40	20
Leptospermum coriaceum	0	20
Hakea laurina	0	0
Hamelia patens	60	0
Holmskioldia sanguinea	100	100
Brachychiton rupestris	100	100
Justicia aurea	0	0
Nyctanthes arboretum	100	100
Murraya exotica	80	60
Phyllanthus nivosus	100	60
Thryptomene baeckeacea	0	0
Russelia equisetiformis	80	100
Tecoma argentina	80	100
Euphorbia characias	100	100

DAP=Days after Planting, SD=Standard Deviation.

A complete randomized block design with five replications of all experimental plant species in both sites was used. Optimum cultural practices were carried out for the transplanted plants. For shrubs, 60 cm diameter basin was taken around the plant and a six inch pot full of peat moss was applied. A teaspoon full of complex fertilizer 15-15-15 was also applied to the base of the plant after raking the soil. Subsequent doses of fertilizer were applied at monthly intervals. Mealy bug infestation was noticed in some of the shrubs and the pest was controlled by spraying Diazinon at the rate of 0.01% at weekly intervals. Experimental plant species were covered with shade net to protect the plants from high temperature and hot winds. Irrigation water amounts were regulated to meet the plants requirements according to the season. Old, unhealthy and dried branches were removed and the shrubs were pruned at a desired height and the shapes of the plant were maintained. Weeding was also done at regular intervals. Data on survival, plant height, stem diameter and phenological observations were documented on bi-monthly basis.

Results and Discussion

The data collected were tabulated and their means, standard deviation, survival percentages and growth rates were calculated. The survival percentages of the plants in both inland and coastal site are presented in Table 1, and Fig. 1 is its graphical representation. It was observed that by the middle of the experimental period 16 species out of the 26 experimental shrubs in the inland site recorded 100% survival. Only one shrub recorded 0%. The remaining shrub survival percentages recorded between 20-80%, but by the end of the study it was observed that only 9 species out of the 26 recorded 100% survival. Six shrubs recorded 0% survival and the remaining shrub survival percentages ranged from 20 to 80%. In the coastal site, 21 species of the experimental shrubs recorded 100% survival during the first half of the experiment. Again only one shrub died during that period. The survival percentages of remaining shrubs recorded between 60-80%. Towards the end of the project 15 species recorded 100% survival. There was 0% survival for four shrubs. 20-80% survival was recorded for remaining shrubs.

Table 2 and 3 indicates the mean, standard deviation and growth rate of the experimental shrubs in the inland and coastal site respectively. Fig. 2 shows the comparison of growth rates of the experimental plants in both the sites. It was observed that in the inland site, towards the middle of the experimental period the species *Hakea laurina* died. This was due to the extreme temperatures prevailed in Kuwait during the months of June, July and August. The plant species *Russelia equisetiformis* showed the maximum survival percentage of 246.54%. The lowest growth rate of -37.18% was observed in *Bambusa vulgaris* Aureo-variegata. By the end of the experiment the plants *Hibiscus rosasinensis variegate*, *Callistemon viminalis* 'Captain Cook', *Leptospermum coriaceum*, *Hakea laurina*, *Justicia aurea* and *Thryptomene baeckeacea* died as they were not able to withstand the extreme climatic conditions. Some plants like *Acacia wilhelmina*, *Hibiscus rosasinensis* variegate, *Banksia ashbyi* and *Gossypium sturtianum* showed more than 200% growth rate.

The plant species *Justicia aurea* died in the coastal site, when the experiment was half way through, as it could not withstand variable climatic conditions. The highest growth rate of 250.97% was recorded for *Acacia wilhelmina*.

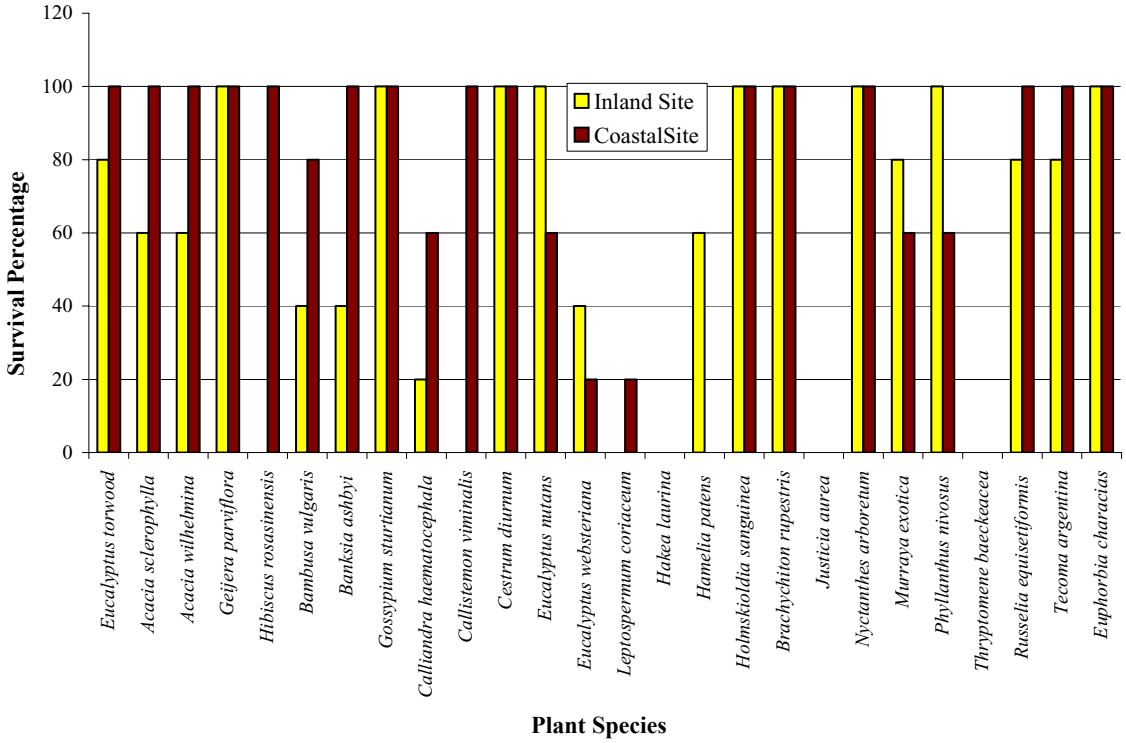

Figure 1. Survival percentages of experimental shrubs in inland and coastal sites.

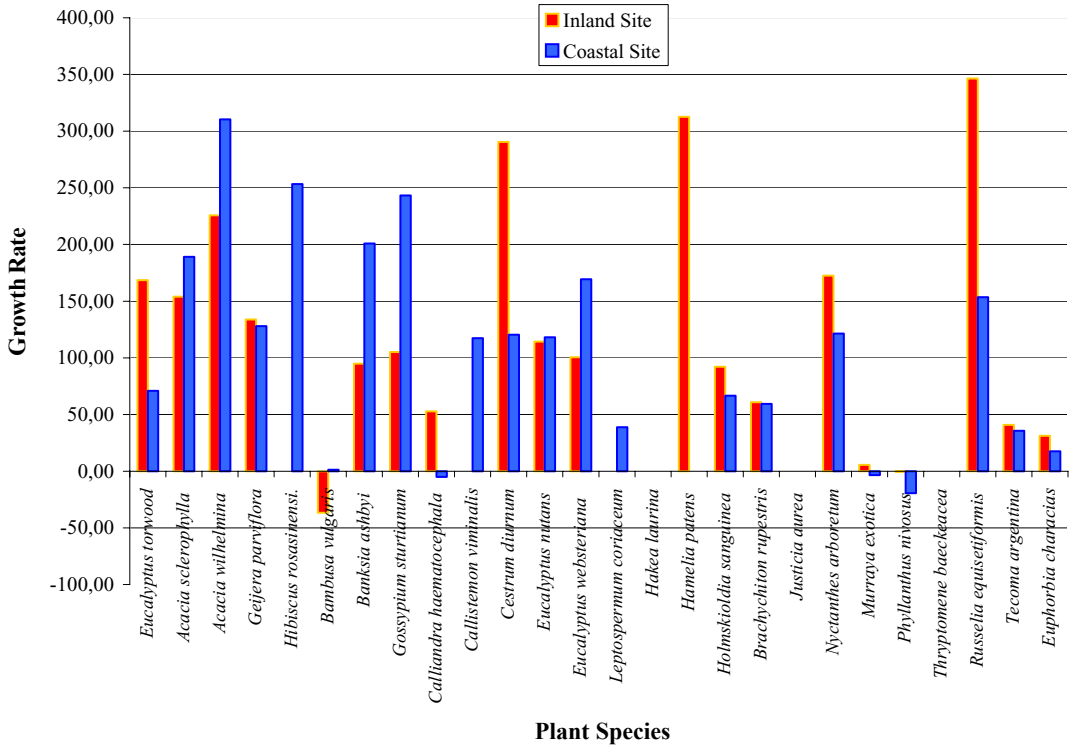

Figure 2. Growth rate of experimental shrubs in inland and coastal sites.

Bambusa vulgaris Aureo-variegata exhibited the lowest growth rate of -19.24%. *Hakea laurina*, *Hamelia patens* and *Thryptomene baeckeacea* were the shrubs which died towards the end of the experiment. Only three plant species namely, *Calliandra haematocephala*, *Murraya exotica* and *Phyllanthus nivosus* had negative growth rates. When compared to the growth rates of the plants in the inland site the plants in the costal site did well even under extreme climatic conditions. The means and standard deviations of plant caliper of the experimental shrubs in the inland and costal site are presented in Table 4 and 5 respectively. Tables 6 and 7 respectively, represent the plant cover of the shrubs under study in the inland and costal site. The effect of high temperature and low temperature on the growth of plants is explained in Table 8 and Table 9 respectively.

Table 2. Periodical means and standard deviations of plant height of the experimental plants in the inland site.

Plant species	Initial		120 DAP		240 DAP		360 DAP		Final		Growth rate (%)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Eucalyptus torwood	45.80	15.30	56.80	12.64	99.20	16.66	148.25	35.52	152.50	35.52	168.49
Acacia sclerophylla	30.00	4.74	41.00	6.82	65.25	20.43	73.00	3.61	74.67	5.13	153.97
Acacia wilhelmina	31.00	12.71	37.60	13.01	87.60	24.47	100.67	21.59	101.00	23.26	225.81
Geijera parviflora	39.20	14.48	32.40	2.07	56.80	4.82	73.80	16.42	75.80	19.66	133.95
Hibiscus rosasinensis variegata	33.40	3.05	18.40	5.68	28.67	10.02	Dead	Dead	Dead	Dead	Dead
Bambusa vulgaris Aureo-variegata	109.20	20.66	82.60	8.85	68.60	11.50	65.50	10.61	61.50	12.02	-36.73
Banksia ashbyi	24.80	3.27	32.00	3.67	39.75	10.72	49.00	12.73	46.00	14.14	94.92
Gossypium sturtianum	48.60	8.41	80.00	2.92	116.40	17.11	108.80	53.84	111.20	11.08	105.17
Calliandra haematocephala	84.40	8.99	81.25	16.94	90.67	13.58	92.50	43.13	140.00	0.00	52.84
Callistemon viminalis 'Captain Cook'	93.40	34.00	135.40	23.14	183.60	36.57	258.80	20.63	Dead	Dead	Dead
Cestrum diurnum	30.80	5.81	67.20	18.81	111.60	18.37	62.40	6.27	262.40	19.09	290.48
Eucalyptus nutans	35.40	7.02	54.20	5.36	84.20	8.38	92.60	8.65	77.60	14.54	114.36
Eucalyptus websteriana	31.50	6.61	47.60	10.78	74.25	4.79	84.50	13.44	73.00	2.83	100.55
Leptospermum coriaceum	31.33	1.15	26.40	3.21	19.50	0.71	Dead	Dead	Dead	Dead	Dead
Hakea laurina	54.20	9.31	61.40	13.03	Dead	Dead	Dead	Dead	Dead	Dead	Dead
Hamelia patens	28.20	3.83	32.80	4.76	42.40	9.07	103.00	9.00	104.00	9.17	312.70
Holmskioldia sanguinea	33.80	4.49	27.00	4.24	41.40	4.72	58.80	6.18	63.40	5.77	92.12
Brachychiton rupestris	56.60	32.10	43.40	9.45	65.60	16.15	70.00	22.51	69.80	24.58	60.83
Justicia aurea	20.20	13.05	26.33	20.55	39.00	0.00	Dead	Dead	Dead	Dead	Dead
Nyctanthes arboretum	44.60	11.65	50.80	8.70	82.60	22.41	128.60	31.09	132.40	31.44	172.43
Murraya exotica	67.20	15.27	74.00	14.67	67.75	10.78	74.25	8.66	67.75	17.21	5.53
Phyllanthus nivosus	62.20	5.89	64.80	6.14	62.80	5.17	71.00	4.47	61.00	25.08	-0.33
Thryptomene baeckeacea	60.60	12.95	57.60	5.41	47.50	17.82	Dead	Dead	Dead	Dead	Dead
Russelia equisetiformis	24.60	8.26	60.50	30.58	85.25	13.74	126.00	12.52	143.75	35.20	346.43
Tecoma argentina	112.80	15.66	118.00	16.67	111.40	16.32	142.60	54.48	149.00	65.43	40.83
Euphorbia characias	30.00	9.77	33.20	5.81	42.80	3.56	45.80	5.07	43.60	6.35	31.33

DAP=Days after Planting, SD=Standard Deviation, Growth Rate={(Final Height-Initial Height)/Initial Height}x100.

Table 3. Periodical means and standard deviations of plant height of the experimental plants in the coastal site.

Plant species	Initial		120 DAP		240 DAP		360 DAP		Final		Growth rate (%)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Eucalyptus torwood	52.60	10.01	66.80	13.22	93.40	13.35	112.80	24.02	114.20	24.49	70.96
Acacia sclerophylla	29.40	3.58	49.20	7.79	77.60	9.21	83.80	9.98	85.00	10.56	189.12
Acacia wilhelmina	31.00	8.31	48.60	8.71	108.80	20.00	123.00	23.70	127.20	25.02	310.32
Geijera parviflora	27.40	13.52	30.00	2.00	57.80	7.01	66.80	8.41	68.40	7.77	128.00
Hibiscus rosasinensis variegata	35.60	2.61	15.00	1.58	37.00	15.23	50.40	23.72	53.00	22.99	253.33
Bambusa vulgaris Aureo-variegata	97.20	13.27	83.60	7.60	78.50	38.24	98.50	47.14	98.50	47.87	1.34
Banksia ashbyi	23.60	6.66	31.40	4.34	61.00	17.86	69.80	20.27	71.00	22.51	200.85
Gossypium sturtianum	54.20	4.66	66.80	5.89	122.60	9.91	179.20	24.35	186.00	24.67	243.17
Calliandra haematocephala	91.60	21.26	102.40	8.08	92.33	3.21	99.33	31.56	87.00	36.37	-5.02
Callistemon viminalis 'Captain Cook'	100.80	13.88	131.40	19.03	168.00	24.65	215.00	21.78	219.00	20.29	117.26
Cestrum diurnum	50.60	11.26	43.20	11.08	88.40	10.09	93.80	9.52	95.20	8.90	120.37
Eucalyptus nutans	36.20	7.98	43.80	4.49	64.75	9.00	78.00	4.58	79.00	5.29	118.23
Eucalyptus websteriana	36.40	5.86	44.00	8.80	69.67	10.21	91.00	0.00	98.00	0.00	169.23
Leptospermum coriaceum	33.00	4.85	34.60	10.19	46.75	15.52	52.00	0.00	48.00	0.00	38.73
Hakea laurina	51.00	10.65	67.60	9.45	93.60	12.82	Dead	Dead	Dead	Dead	Dead
Hamelia patens	25.20	8.01	28.40	5.37	31.80	2.39	Dead	Dead	Dead	Dead	Dead
Holmskioldia sanguinea	33.00	4.30	36.00	4.24	42.80	3.19	54.00	7.87	55.00	7.84	66.67
Brachychiton rupestris	41.00	13.21	42.40	6.43	63.40	11.28	66.60	8.32	67.60	9.71	59.43
Justicia aurea	28.40	28.43	15.00	6.32	Dead	Dead	Dead	Dead	Dead	Dead	Dead
Nyctanthes arboretum	48.60	8.53	41.40	7.13	69.20	14.48	92.20	13.81	107.60	8.82	121.40
Murraya exotica	64.20	12.70	68.60	9.84	59.00	8.19	62.33	19.55	62.00	20.66	-3.43
Phyllanthus nivosus	61.20	7.29	64.60	7.50	56.20	4.49	49.33	5.69	49.33	6.03	-19.39
Thryptomene baeckeacea	64.00	7.81	58.20	9.47	76.33	25.58	Dead	Dead	Dead	Dead	Dead
Russelia equisetiformis	32.20	5.93	42.20	9.71	71.00	24.53	78.80	15.48	81.60	16.64	153.42
Tecoma argentina	105.80	8.58	116.00	11.14	122.00	17.44	143.20	14.82	143.60	13.58	35.73
Euphorbia characias	36.60	8.44	31.80	5.45	37.80	3.70	36.00	8.60	37.40	6.58	17.61

DAP=Days after Planting, SD=Standard Deviation, Growth Rate={(Final Height-Initial Height)/Initial Height}x100.

Table 4. Periodic stem diameter means and standard deviations of experimental shrubs in the inland site.

Plant species	Initial		120 DAP		240 DAP		360 DAP		Final	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eucalyptus torwood	4.00	0.00	4.80	0.84	8.80	1.48	16.50	3.11	17.00	2.71
Acacia sclerophylla	3.20	1.30	4.40	1.14	7.50	2.52	14.00	1.00	14.00	1.00
Acacia wilhelmina	2.20	0.84	6.20	2.05	12.20	3.96	20.33	2.31	20.67	2.08
Geijera parviflora	5.40	0.89	5.00	0.71	10.20	1.30	14.60	1.95	14.80	1.92
Hibiscus rosasinensis variegata	4.00	0.00	5.20	0.84	8.00	1.73	Dead	Dead	Dead	Dead
Bambusa vulgaris Aureo-variegata	10.80	1.30	10.80	1.30	10.80	1.30	13.00	2.83	13.00	2.83
Banksia ashbyi	3.60	0.55	5.80	0.45	6.50	0.58	8.50	2.12	9.00	1.41
Gossypium sturtianum	4.80	0.84	9.00	0.00	11.60	1.14	16.00	1.22	16.00	1.22
Calliandra haematocephala	5.80	0.45	8.25	0.96	11.00	1.73	15.00	1.41	24.00	0.00
Callistemon viminalis 'Captain Cook'	6.80	1.10	14.40	2.51	21.60	2.07	31.00	5.34	Dead	Dead
Cestrum diurnum	2.80	1.30	6.00	0.71	10.40	2.07	14.00	0.71	31.60	4.51
Eucalyptus nutans	3.00	0.71	7.40	0.89	11.40	1.52	14.60	0.89	14.60	0.89
Eucalyptus websteriana	2.50	0.58	4.40	0.89	7.50	1.29	13.50	0.71	13.50	0.71
Leptospermum coriaceum	3.67	0.58	3.00	0.00	3.00	0.00	Dead	Dead	Dead	Dead
Hakea laurina	4.60	0.89	7.40	1.14	Dead	Dead	Dead	Dead	Dead	Dead
Hamelia patens	5.20	0.84	7.60	0.55	11.20	1.10	19.33	1.53	21.67	1.15
Holmskioldia sanguinea	3.20	0.45	3.80	0.45	4.40	0.55	6.20	0.84	6.80	0.45
Brachychiton rupestris	8.00	3.46	6.60	0.89	10.60	1.95	15.40	3.91	15.40	3.91
Justicia aurea	5.20	1.30	8.00	1.00	9.00	0.00	Dead	Dead	Dead	Dead
Nyctanthes arboretum	4.00	1.00	5.60	0.55	9.20	1.92	16.00	3.32	16.20	3.27
Murraya exotica	4.60	0.55	5.25	0.50	8.00	0.82	12.00	1.15	13.50	2.52
Phyllanthus nivosus	5.80	0.45	9.40	0.89	11.40	1.52	33.60	43.84	14.80	2.95
Thryptomene baeckeacea	6.00	0.71	5.00	0.00	5.00	2.58	Dead	Dead	Dead	Dead
Russelia equisetiformis	3.20	1.30	4.50	1.29	5.50	1.29	11.75	1.71	11.75	1.71
Tecoma argentina	9.40	0.89	12.40	1.67	13.40	1.52	16.40	2.51	14.50	3.32
Euphorbia characias	4.00	0.71	18.60	0.55	21.20	0.84	23.00	1.00	24.80	1.79

DAP=Days after Planting, SD=Standard Deviation.

Table 5. Periodic stem diameter means and standard deviations of experimental shrubs in the coastal site.

Plant species	Initial		120 DAP		240 DAP		360 DAP		Final	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eucalyptus torwood	4.00	1.00	4.40	0.89	8.00	1.22	10.60	1.82	11.00	2.35
Acacia sclerophylla	3.80	1.64	6.00	1.00	10.00	0.71	15.00	1.00	15.00	1.00
Acacia wilhelmina	3.60	0.55	6.60	0.89	15.40	2.61	22.20	4.49	22.40	4.39
Geijera parviflora	6.40	1.82	5.80	0.45	10.80	1.10	11.80	0.84	12.60	0.55
Hibiscus rosasinensis variegata	5.20	0.45	4.60	0.55	5.60	0.89	7.60	1.34	7.80	1.10
Bambusa vulgaris Aureo-variegata	12.60	0.89	12.20	1.48	9.75	3.20	9.50	3.11	9.50	3.11
Banksia ashbyi	3.60	0.55	6.00	1.22	7.80	1.64	10.40	2.70	10.80	2.95
Gossypium sturtianum	5.60	0.55	7.20	0.45	20.60	1.52	29.40	2.70	31.60	3.91
Calliandra haematocephala	6.60	2.19	9.40	1.82	10.00	1.00	12.33	1.53	13.67	3.79
Callistemon viminalis 'Captain Cook'	7.20	0.84	13.80	1.30	21.80	2.17	30.20	1.48	30.40	1.52
Cestrum diurnum	4.00	0.71	6.00	1.41	11.20	1.30	13.20	1.48	13.60	1.52
Eucalyptus nutans	3.40	0.55	6.20	0.84	11.00	2.00	14.00	1.00	14.33	0.58
Eucalyptus websteriana	2.80	0.45	3.80	0.84	9.00	1.73	14.00	0.00	14.00	0.00
Leptospermum coriaceum	3.60	1.14	3.40	0.55	4.25	0.50	5.00	0.00	5.00	0.00
Hakea laurina	5.00	0.71	8.40	1.14	14.40	1.95	Dead	Dead	Dead	Dead
Hamelia patens	5.00	0.71	5.20	0.45	6.00	0.00	Dead	Dead	Dead	Dead
Holmskioldia sanguinea	4.20	0.45	4.60	0.55	5.40	0.55	5.80	0.45	6.20	0.45
Brachychiton rupestris	8.40	2.30	6.40	0.55	12.80	1.92	16.80	3.96	17.40	4.51
Justicia aurea	7.60	1.52	5.60	1.52	Dead	Dead	Dead	Dead	Dead	Dead
Nyctanthes arboretum	4.80	1.10	5.00	0.71	8.00	2.35	10.60	2.07	12.00	1.58
Murraya exotica	5.80	0.45	5.80	0.45	8.33	0.58	9.33	0.58	9.33	0.58
Phyllanthus nivosus	6.20	1.64	6.80	1.30	8.20	0.45	9.67	0.58	9.67	0.58
Thryptomene baeckeacea	7.20	1.10	5.80	0.84	7.33	1.53	Dead	Dead	Dead	Dead
Russelia equisetiformis	3.00	0.71	4.20	0.84	5.60	1.14	7.20	2.05	8.00	1.58
Tecoma argentina	11.40	0.89	11.80	0.84	14.40	1.95	16.00	2.55	17.20	3.56
Euphorbia characias	5.00	1.41	18.20	0.84	20.80	1.30	22.80	1.79	22.80	1.79

DAP=Days after Planting, SD=Standard Deviation.

Table 6. Periodic plant canopy means and standard deviations of experimental shrubs in the inland site.

Plant species	120 DAP		240 DAP		360 DAP		Final	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eucalyptus torwood	16.60	5.55	43.00	7.91	72.75	26.13	69.75	31.46
Acacia sclerophylla	26.80	6.76	52.75	1.89	57.67	6.11	84.33	15.89
Acacia wilhelmina	34.40	6.02	58.40	15.90	97.33	13.05	99.33	13.80
Geijera parviflora	12.00	2.92	28.60	2.79	54.80	10.66	56.20	13.26
Hibiscus rosasinensis variegata	12.60	3.58	32.33	3.06	Dead	Dead	Dead	Dead
Bambusa vulgaris Aureo-variegata	17.40	5.08	16.40	9.61	30.50	34.65	26.00	28.28
Banksia ashbyi	24.80	6.30	33.75	6.90	51.50	24.75	55.50	24.75
Gossypium sturtianum	17.20	3.63	57.00	5.96	87.80	7.46	64.00	13.58
Calliandra haematocephala	21.50	8.35	38.33	20.26	56.00	11.31	129.00	0.00
Callistemon viminalis 'Captain Cook'	61.40	18.15	81.40	6.23	144.60	18.23	Dead	Dead
Cestrum diurnum	21.00	7.68	37.60	6.84	24.20	7.40	149.80	18.62
Eucalyptus nutans	43.80	10.38	63.80	6.10	77.40	5.98	70.60	17.42
Eucalyptus websteriana	23.60	12.70	34.00	2.16	40.50	0.71	51.50	4.95
Leptospermum coriaceum	12.80	2.28	26.00	1.41	Dead	Dead	Dead	Dead
Hakea laurina	13.80	2.59	Dead	Dead	Dead	Dead	Dead	Dead
Hamelia patens	32.60	4.04	45.00	4.90	132.67	12.01	134.00	12.12
Holmskioldia sanguinea	24.80	4.09	36.60	7.99	40.40	8.85	56.20	7.76
Brachychiton rupestris	27.60	5.55	32.20	7.40	27.80	13.79	32.80	14.50
Justicia aurea	12.00	9.54	2.00	0.00	Dead	Dead	Dead	Dead
Nyctanthes arboretum	21.60	5.03	45.40	4.56	81.00	18.26	83.00	20.45
Murraya exotica	13.75	2.75	15.50	2.52	27.75	2.06	43.75	9.03
Phyllanthus nivosus	22.00	2.35	22.40	5.18	37.40	4.62	37.20	10.80
Thryptomene baeckeacea	17.60	1.82	16.00	4.69	Dead	Dead	Dead	Dead
Russelia equisetiformis	53.50	21.49	67.75	2.36	88.00	11.22	115.50	27.74
Tecoma argentina	34.00	15.05	24.20	6.83	53.20	23.93	58.50	31.43
Euphorbia characias	23.00	2.74	36.60	4.28	38.80	2.49	41.40	5.03

DAP=Days after Planting, SD=Standard Deviation.

Table 7. Periodic plant canopy means and standard deviations of experimental shrubs in the coastal site.

Plant species	120 DAP		240 DAP		360 DAP		Final	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eucalyptus torwood	26.20	2.86	40.00	8.63	52.20	12.07	59.80	9.42
Acacia sclerophylla	44.40	3.21	54.60	2.79	82.40	17.02	83.60	17.01
Acacia wilhelmina	34.00	3.39	90.00	17.82	129.40	14.84	134.00	16.51
Geijera parviflora	18.20	3.03	27.60	3.36	53.00	15.62	56.60	15.37
Hibiscus rosasinensis variegata	9.60	2.41	37.60	23.56	50.80	24.08	52.60	22.63
Bambusa vulgaris Aureo-variegata	26.40	2.97	25.50	14.73	52.25	15.54	50.25	12.09
Banksia ashbyi	25.80	2.17	31.20	3.11	45.60	4.72	47.60	6.54
Gossypium sturtianum	23.40	5.98	76.00	6.04	121.80	14.97	144.20	21.05
Calliandra haematocephala	12.80	5.07	18.33	4.04	56.33	35.23	69.00	72.81
Callistemon viminalis 'Captain Cook'	63.40	12.10	80.80	9.47	122.20	6.06	124.60	6.84
Cestrum diurnum	26.00	0.71	50.20	4.02	66.00	8.69	66.20	8.14
Eucalyptus nutans	23.60	3.58	59.00	9.35	90.67	27.06	94.67	30.66
Eucalyptus websteriana	20.40	5.86	35.67	1.53	65.00	0.00	69.00	0.00
Leptospermum coriaceum	14.80	4.09	29.25	9.71	29.00	0.00	26.00	0.00
Hakea laurina	25.80	3.63	44.80	6.72	Dead	Dead	Dead	Dead
Hamelia patens	15.20	4.87	35.80	2.86	Dead	Dead	Dead	Dead
Holmskioldia sanguinea	36.20	3.96	39.40	3.97	54.60	6.43	54.60	5.59
Brachychiton rupestris	42.40	5.03	24.00	5.52	23.20	16.89	24.00	17.94
Justicia aurea	12.40	2.70	Dead	Dead	Dead	Dead	Dead	Dead
Nyctanthes arboretum	7.80	1.10	41.60	9.18	51.00	12.41	57.60	8.05
Murraya exotica	5.40	2.07	11.00	7.81	16.33	3.79	17.33	4.04
Phyllanthus nivosus	8.20	2.39	18.00	2.12	24.33	7.09	18.67	1.53
Thryptomene baeckeacea	36.00	5.52	35.67	4.51	Dead	Dead	Dead	Dead
Russelia equisetiformis	26.40	6.69	55.20	19.74	78.00	24.57	80.60	24.85
Tecoma argentina	34.80	5.81	44.80	2.28	53.60	5.64	50.80	6.98
Euphorbia characias	8.60	1.14	34.60	5.03	33.60	1.95	34.40	5.32

Dap=Days after Planting, SD=Standard Deviation.

Table 8. The effect of high temperature on the growth of experimental shrubs.

Plant species	Effects of temperature
Eucalyptus torwood	Not affected by heat.
Acacia sclerophylla	Good growth. More branches had developed and grew laterally covering more area. Effect of heat on plants not noticeable.
Acacia wilhelmina	Excellent growth. More lateral growth and the leaves are good and green in color.
Geijera parviflora	No drying. Some leaves which are directly exposed to sunlight were affected. More branches were formed and newly formed leaves were greener.
Hibiscus rosasinensis variegata	Good bushy green growth. More branches. Not affected by heat.
Bambusa vulgaris Aureo-variegata	Total loss of plants.
Banksia ashbyi	Very good growth when compared with the winter season. Increase in height of the plants. Have developed more branches. A slight discoloration of the leaves was noticed.
Gossypium sturtianum	Excellent growth. There was no effect of heat. Increase in the stem thickness was noticed.
Calliandra haematocephala	Affected by heat. Two plants were dead. The upper leaves had dried. Drying starts from leaf margins.
Callistemon viminalis 'Captain Cook'	Excellent growth. More branches.
Cestrum diurnum	Yellowing of leaves was noticed. New sprouts can be seen from the base of the plants. Leaves shows wrinkling which on later stages turn into a cup like structure.
Eucalyptus nutans	Not much affected by high temperature. Slight burning of leaves due to heat, but normal canopy development was good.
Eucalyptus websteriana	Some leaves were dried. Loss of vigor of plant was noticed.
Leptospermum coriaceum	Total drying of leaves and stem. Drying starts from the top of the plant.
Hakea laurina	Total loss of plant.
Hamelia patens	Leaves dried. But the flowers were still in the plant. The shape and structure of the plant was lost. New sprouts can be seen in the axils.
Holmskioldia sanguinea	Dried leaf tips. New healthy shoots are coming. Dark discoloration of the leaves was due to burning.
Brachychiton rupestris	All the leaves were dried, but the stem remains green. The drying starts from margins of leaves leading to total drying of leaf lamina, leaving only the veins of leaves on plant.
Justicia aurea	Total drying of the plant.
Nyctanthes arboretum	Good growth of the plants. B bushy green growth was noticed. Old leaves show senescence without drying. Fully expanded leaf lamina was seen.
Murraya exotica	Retarded growth of the plants. Leaves show partial drying and shedding. Only the main stem remains.
Phyllanthus nivosus	No leaf on the plants, but the stem remains healthy.
Thryptomene baeckeacea	Stem and leaves were dried. Stem shows dark discoloration.
Russelia equisetiformis	Good growth. Increase in the height of the plant. More shoots were emerging from the base of the plant. Increase in the length of the inter-nodal region.
Tecoma argentina	No increase in stem growth was noticed. But there was an increase in the stem thickness in the upper part of the main stem.
Euphorbia characias	Partial drying of leaves. Numerous new shoots are coming from the base giving the plants a bushy appearance. Leaves turned to pale green. Loss of vigor of plants.

Table 9. The effect of low temperature on the growth of experimental shrubs.

Plant species	Effects of low temperature
Eucalyptus torwood	Good growth. Characteristic green leaves were developed. Increase in height of the plant was noticed
Acacia sclerophylla	Good growth. The branches were well developing and spread. No effect of cold on the growth.
Acacia wilhelmina	Excellent growth. Branches spread to more area. Well developed greenish leaves noticed.
Geijera parviflora	Very good growth. Branches were well developing from the entire stem. Healthy leaves.
Hibiscus rosasinensis variegata	Characteristic variegated leaves were formed. No effect of cold on the growth and development. Increase in height of the plant was noticed.
Bambusa vulgaris Aureo-variegata	Numerous suckers were developed from the base. The suckers were actively growing.
Banksia ashbyi	Greener leaves compared to summer. Increase in height of the plants was noticed.
Gossypium sturtianum	Excellent growth. Increase in height of the plants was noticed. Well development of the trunk. Numerous sprouts were formed from the basal region.
Calliandra haematocephala	No prominent growth. Stem tips were dried. Branches were produced from entire region gave the plant a bushy appearance.
Callistemon viminalis 'Captain Cook'	Good growth. No effect of cold on the growth of the plant. Well developed trunk and branches.
Cestrum diurnum	Normal growth.
Eucalyptus nutans	The margins of leaves were dried. Development of lateral branches gave a wider canopy to the plant.
Eucalyptus websteriana	No effect. The leaves were greener.
Leptospermum coriaceum	Plants lost vigor. Almost stunted growth throughout the period.
Hakea laurina	Total loss of plant.
Hamelia patens	Good growth.
Holmskioldia sanguinea	Excellent growth. The leaves were more greenish than that in the summer.
Brachychiton rupestris	Very good growth. Well developed stem and leaves. Good young leaves were coming from axils.
Justicia aurea	Total loss during summer.
Nyctanthes arboretum	Even though the plants flowered, as the season progressed the leaves started drying. The drying started from the margins and then covered the entire area. New leaves were produced. The stem was also healthy.
Murraya exotica	Almost retarded growth. The leaves showed chlorosis. The dried leaves were seen hanging on the plant
Phyllanthus nivosus	Good growth. The tip of the stems was dried. The leaves showed characteristic mosaic pattern.
Thryptomene baeckeacea	Total loss during summer.
Russelia equisetiformis	Excellent growth. Additional suckers were produced from the base. The stems extended upwards. The plants were flowered.
Tecoma argentina	The plants were healthy but the rate of growth was very slow. Additional branches were produced from the middle part of the stem.
Euphorbia characias	Excellent growth. Additional production of flowers during this season. More branches were produced and all the branches bore flowers.

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