WFL Publisher
Science and Technology
Meri-Rastilantie 3 C, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.5 (1) : . 2007

www.world-food.net

Screening of potential ornamental trees for Kuwait's climatic conditions

M. K. Suleiman *, N. R. Bhat, M. S. Abdal, L. Al-Mulla, R. Grina, R. Bellen, G. D'Cruz, J. George and A. Christopher

*Agriculture and Biodiversity Department, Food Resources and Biological Sciences Division, Kuwait Institute for Scientific Research, Kuwait. *e-mail: mkhalil@safat.kisr.edu.kw*

Recieved....accepted...

Abstract

Kuwait is an arid country with severely harsh climate. Summer months are extremely hot, accompanied with frequent sandstorms, and winter is mild with relatively low rainfall (100 mm/yr). These adverse climatic conditions call for additional criteria for plants to be used in the country. Several new residential areas are being established in Kuwait due to the increase in the population and urbanization. These areas require massive greenery activities to alleviate architectural structures and enhance their microclimate. Additionally, several other landscape projects are being executed in response to the national greenery plan. This study was conducted on ornamental trees exported from India and Australia to ascertain their adaptability to Kuwait's climate. The importance of such an endeavor stems from the fact that trees beautify the country's surroundings, increase property values and help save energy. A total of twenty five species of trees were tested in the urban development garden (coastal site) and also in the inland site to study their suitability in both sites. Out of the twenty five trees in the inland site, seven species did not survive the prevailing environment, whereas six trees showed hundred percent survivals and the survival percentage of twelve species varied between 40 and 80%. On the other hand, the survival rate of the majority of the tested tree species was almost 100 % at the coastal site.

Key words: Residential, urbanization, landscape, microclimate, trees, inland site, coastal site, energy.

Introduction

Kuwait has extreme climatic conditions, with limited resources available for crop production. The soil is mostly sandy in texture and contains low amount of nutrients. The climatic conditions are typical of an arid environment with high temperature during the summer season, very low rainfalls, frequent winds and soil erosion. 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, as a greater diversification of the locally adapted ornamental plant palette is greatly needed [4]. Plant species richness and diversity is positively related to new urban development areas. Additionally, the distribution of the species in the urban landscape follows necessities of city and human quality [1]. Trees are important components of the natural landscape and significant elements in landscaping and agriculture [6]. Trees, especially hardwoods, undergo many changes over the course of the year. These changes are adaptations to meet the tree's needs and in response to the harshness of the climate.

Man has been the primary agent in the creation of new plants and new plant communities [2]. Garden floras interact with native biodiversity by providing resources for wildlife and by acting as a source of non- native species [5]. Trees have a single stem, grow to heights greater than 10 feet and they are perennial. The importance of longevity of the plants in combination with good shape, vigor and good health is emphasized, particularly for projects in which the economic benefit is largely indirect, e.g. for soil conservation and landscaping [3]. Carefully chosen species can play a decisive role in environmental restoration and protection in arid and semi-arid regions. Introduced from habitats of similar environments and subsequently selected for their adaptability to hot arid area, such species considerably enlarge the range of possible re-vegetation candidates and open new opportunities for diversification of the vegetation. Thus this study emphasized on the adaptability of the introduced tree species and their suitability to Kuwait's climatic conditions.

Methodology

Twenty five tree species listed in Table 1 were selected for the study. These tree species were imported from Australia and India. The plants were allowed to harden by keeping them in greenhouse conditions. The site was first cleared off from weeds, thrash, rock clods and other debris. The site was excavated to varying depths and local agricultural soil was used as a replacement. In the planting holes, 30 cm of the top layer was backfilled with agricultural soil and the site was then leveled. 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 plants at the inland and coastal sites.

List of trees	Survival (%)	
	Inland site	Coastal site
Acacia biflora	0	100
Adenium obesum	60	100
Tabebuia rosea	80	100
Pittosporum tobira	80	60
Angophora costata	0	0
Alstonia scholaris	60	100
Thespesia populnea	100	100
Bursaria spinosa	0	20
Callistemon citrinus 'Mauve Mist'	0	0
Callistemon lilacinus	100	100
Callistemon salignus	60	100
Brachychiton acerifolius	20	0
Bambusa vulgaris variegata	0	0
Delonix regia	60	100
Dolichandrone spathacea	20	40
Grevillea robusta	40	20
Hymenosporum flavum	40	0
Jatropha multifida	100	100
Lagerstroemia thorelli	0	0
Lophostemon confertus	20	0
Millingtonia hortensis	100	100
Mimusops elengi	60	100
Peltophorum pterocarpum	100	100
Pithecellobium saman	0	100
Pittosporum phylliraeoides	100	100

Optimum cultural practices were carried out for each plant species. For trees, slow releasing fertilizer tablets were applied at a rate of one tablet per tree at a distance of 30 cm from the base of the plant. Peat moss was applied to the trees by selecting a 1-meter basin around the plants and peat moss was applied at a rate of two six inch pots full per plant. The fertilizer was applied one day after the application of peat moss. Fertilizer was applied along the sides of the basin, and the soil was raked. Subsequent doses of fertilizer were applied at monthly intervals. Old, unhealthy and dried branches were removed and the trees were pruned at a desired height while maintaining the shape of the plants. Data on survival rates, plant height, stem diameter and phenological observations were documented on a bi-monthly basis.

Results and Discussions

Data obtained on the survival rate percentage (Table 1) at the inland site showed that the tree species *Acacia biflora*, *Angophora costata*, *Bursaria spinosa*, *Callistemon citrinus*, *Bambusa vulgaris* variegate, *Lagerstroemia thorelli* and *Pithecellobium saman* were not able to withstand the immense prevailing heat during the months of June, July and August and they died. *Thespesia populnea*, *Callistemon lilacinus*, *Jatropha multifida*, *Millingtonia hortensis* and *Pittosporum phylliraeoides* showed a survival rate of 100% even under adverse conditions. All other plant species showed survival rates ranging between 40-80%. At the coastal site, *Angophora costata, Callistemon citrinus, Brachychiton acerifolius, Bambusa vulgaris* variegate, *Hymenosporum flavum*, *Largestroemia thorelli* and *Lophostemon confertus* showed 0% survival rate. Out of the twenty five plant species, fourteen species showed 100% survival rate. For all the other species, the survival rate ranged from 20-80%. A comparison of the survival percentages of tested tree species in both the sites are presented in Fig. 1.

Periodic plant height and growth rate of the plant species at the inland and coastal sites are presented in Tables 2 and 3, respectively. A graphical presentation of these results is shown in Fig 2. At the inland site, the tree species *Pittosporum phylliraeoides* showed the highest growth rate of 224.60%, followed by *Dolichandrone spathacea* which showed a growth rate of 150.52%. Some of the plant species like *Tabebuia rosea*, *Brachychiton acerifolius*, *Delonix regia*, *Grevillea robusta* and *Peltophorum pterocarpum* exhibited negative growth rates. The periodic stem diameter and plant canopy are presented in Tables 4-7. The effect of high and low temperatures on the growth and development of the tree species are presented in Tables 8 and 9, respectively.

References

[1]Acar, C., Acar, H. and Eroglu, E. 2005. Evaluation of ornamental plant resources to urban biodiversity and cultural changing: A case study of residential landscapes in Trabzon city (Turkey). Building and Environment (In press).

[2]Whitney, G. G. and Adams, S. D. 1980. Man as a maker of new plant communities. Journal of Applied Ecology **17**(2):431-448.

[3]Forti, M., Lavie, Y., Ben-Dov, Y. and Pauker, R. 2006. Long-term plant survival and development under dry land conditions in an experimental site in the semi-arid Negev of Israel. Journal of Arid Environments **65**(1):1-28.

[4]Khalil, M., Bhat, N. R., Al-Mulla, L. A., Al-Dossery, S., Bellen, R., Al-Zalzalah, M., D'Cruz, G. and Cruz, R. 2006. Evaluation of New Ornamental Plants for Use in Kuwait's Landscape and Demonstration Gardens Establishment (FA024C). Kuwait Institute for Scientific Research, Progress Report No. V. KISR 8084, Kuwait.

[5]Smith, R. M., Thompson, K., Hodgson, J. G., Warren, P. H. and Gaston, K. J. 2005. Urban domestic gardens (IX): Composition and richness of the vascular plant flora, and implications for native biodiversity. Biological Conservation **129**(3):312-322.

[6]Pakenham, T. 2002. Remarkable Trees of the World. W. W. Norton & Company, Inc. New York, New York, U.S.A.

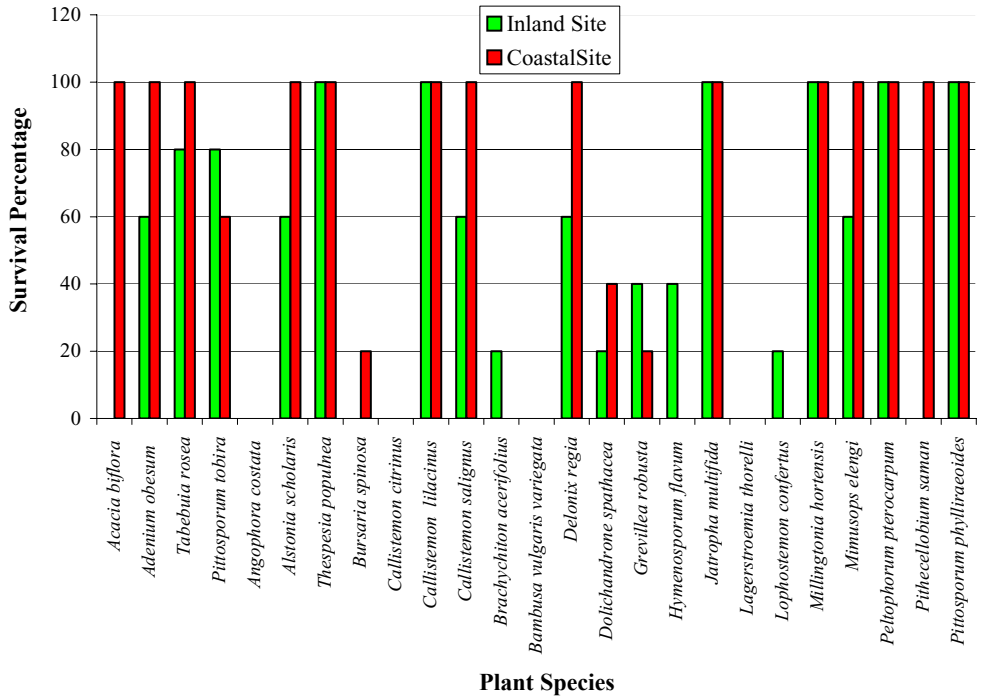

Figure 1. Survival percentages of experimental trees in inland and coastal sites.

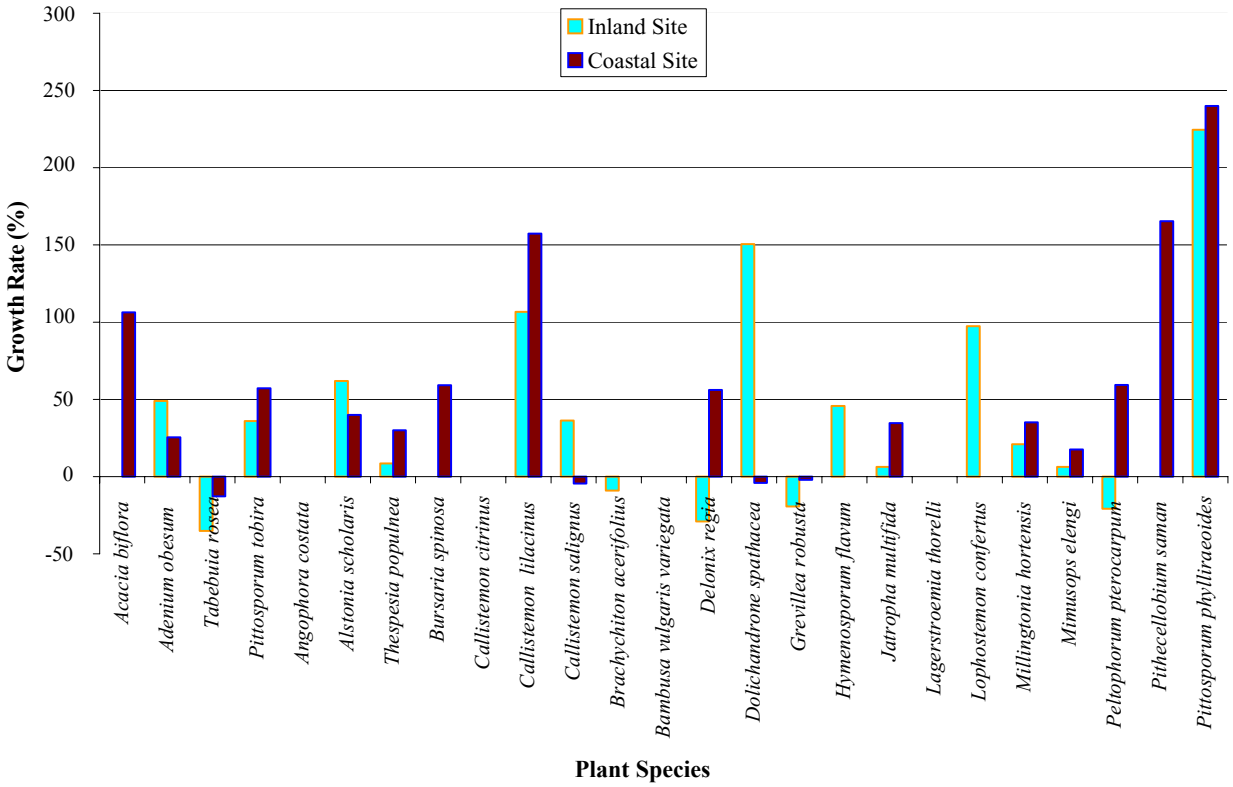

Figure 2. Growth rate of experimental trees in inland and coastal sites**.**

Table 2. Periodic height and growth rate of experimental trees in the inland site.

Latin name	Initial		120 DAP		240 DAP		360 DAP		Final		Growth rate (%)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Acacia biflora	43.00	25.70	69.40	23.21	Dead	Dead	Dead	Dead	Dead	Dead	Dead
Adenium obesum	47.40	9.29	43.33	3.21	48.00	2.00	56.33	3.06	56.33	3.79	49.03
Tabebuia rosea	105.40	7.33	105.25	1.26	64.75	11.09	75.00	11.34	68.25	12.12	-35.25
Pittosporum tobira	56.20	8.11	62.60	15.47	65.80	16.27	65.00	13.88	62.00	10.86	35.96
Angophora costata	35.40	12.92	43.20	11.45	Dead	Dead	Dead	Dead	Dead	Dead	Dead
Alstonia scholaris	85.00	21.31	88.80	23.97	113.80	35.71	133.33	45.09	135.33	44.09	61.88
Thespesia populnea	113.00	102.40	115.40	18.34	117.00	21.40	124.40	21.88	125.40	21.89	8.48
Bursaria spinosa	46.60	7.23	67.25	11.44	57.00	5.23	Dead	Dead	Dead	Dead	Dead
Callistemon citrinus 'Mauve Mist'	15.60	4.34	43.75	3.77	51.50	2.12	Dead	Dead	Dead	Dead	Dead
Callistemon lilacinus	57.20	12.79	98.60	19.32	111.80	45.61	153.20	22.22	142.20	23.64	106.69
Callistemon salignus	66.00	11.94	79.60	13.56	91.80	21.24	93.67	29.37	85.00	32.08	36.22
Brachychiton acerifolius	5.42	7.12	50.60	7.16	63.40	4.72	49.00	0.00	46.00	0.00	-9.09
Bambusa vulgaris variegata	60.40	12.01	30.40	12.58	27.50	3.54	Dead	Dead	Dead	Dead	Dead
Delonix regia	132.60	9.79	116.60	32.39	121.40	49.15	105.33	56.23	106.33	56.15	-29.11
Dolichandrone spathacea	94.00	28.49	92.60	45.84	134.25	56.58	230.00	0.00	239.00	0.00	150.52
Grevillea robusta	95.80	17.02	116.20	22.73	143.80	49.55	77.00	8.49	75.00	14.14	-19.35
Hymenosporum flavum	47.40	8.68	86.20	19.07	116.80	18.06	41.50	16.26	42.00	16.97	45.83
Jatropha multifida	61.00	7.11	72.20	6.72	89.00	7.45	77.20	6.94	75.00	4.47	6.23
Lagerstroemia thorelli	39.80	29.11	28.80	13.20	23.00	5.66	Dead	Dead	Dead	Dead	Dead
Lophostemon confertus	41.00	9.06	82.20	17.75	104.25	47.35	98.00	0.00	90.00	0.00	97.37
Millingtonia hortensis	155.00	11.47	157.20	11.14	159.00	11.25	179.40	11.84	179.00	9.62	20.95
Mimusops elengi	83.60	8.32	93.00	13.89	97.20	14.58	95.33	11.68	94.33	10.69	6.23
Peltophorum pterocarpum	95.60	12.26	84.60	21.62	121.40	26.39	95.60	44.04	97.00	44.59	-20.88
Pithecellobium saman	90.00	30.09	63.00	22.54	82.33	37.69	82.00	0.00	Dead	Dead	Dead
Pittosporum phylliraeoides	32.00	8.92	70.20	26.90	112.20	10.40	119.80	39.92	121.40	41.10	224.60

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

Table 3. Plant height and growth rate of experimental trees in the inland site.

Latin name	Initial		120 DAP		240 DAP		360 DAP		Final		Growth Rate (%)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Acacia biflora	56.60	27.61	72.80	18.13	87.80	18.90	112.80	15.30	116.80	15.83	106.36
Adenium obesum	37.80	7.33	36.00	7.38	45.80	2.68	46.40	1.52	47.40	1.52	25.40
Tabebuia rosea	105.40	7.33	83.00	29.00	81.20	29.41	97.80	20.43	92.00	25.48	-12.71
Pittosporum tobira	45.60	15.27	58.00	17.78	63.60	18.31	71.00	6.56	71.67	4.16	57.16
Angophora costata	40.80	5.93	45.40	5.08	56.00	0.00	Dead	Dead	Dead	Dead	Dead
Alstonia scholaris	83.60	7.77	88.60	9.81	100.20	10.52	116.20	6.80	117.00	8.34	39.95
Thespesia polulnea	115.60	16.46	119.40	15.92	127.60	28.12	152.80	28.09	150.20	26.20	29.93
Bursaria spinosa	39.60	5.59	46.40	12.34	36.40	17.27	59.00	0.00	63.00	0.00	59.09
Callistemon citrinus 'Mauve Mist'	16.80	5.22	32.80	6.06	32.80	3.03	Dead	Dead	Dead	Dead	Dead
Callistemon lilacinus	68.80	7.05	73.80	6.87	165.80	16.16	174.60	10.92	177.00	10.58	157.27
Callistemon salignus	62.40	8.56	79.20	17.77	92.60	15.95	175.60	10.50	59.60	25.59	-4.49
Brachychiton acerifolius	48.20	7.60	50.40	3.78	55.80	8.64	69.80	29.16	Dead	Dead	Dead
Bambusa vulgaris variegata	48.80	3.77	30.80	11.82	Dead	Dead	Dead	Dead	Dead	Dead	Dead
Delonix regia	150.00	13.66	154.60	11.78	183.40	15.85	231.20	26.78	234.20	28.23	56.13
Dolichandrone spathacea	95.40	25.93	102.00	34.93	94.80	37.94	100.00	59.40	91.50	68.59	-4.09
Grevillea robusta	93.00	7.42	110.00	5.79	140.25	12.55	102.00	0.00	91.00	0.00	-2.15
Hymenosporum flavum	28.80	5.45	48.40	6.66	59.40	10.04	Dead	Dead	Dead	Dead	Dead
Jatropha multifida	70.60	3.44	65.00	3.32	88.80	7.85	99.40	5.03	95.00	1.58	34.56
Lagerstroemia thorelli	65.20	40.71	68.80	33.60	92.00	22.52	44.50	9.19	Dead	Dead	Dead
Lophostemon confertus	45.60	3.36	59.20	6.14	110.33	20.01	56.00	0.00	Dead	Dead	Dead
Millingtonia hortensis	148.00	54.35	170.00	24.28	178.00	21.53	205.00	31.15	200.00	24.44	35.14
Mimusops elengi	88.80	8.93	86.40	5.03	97.40	4.88	103.40	4.56	104.40	3.85	17.57
Peltophorum pterocarpum	122.60	32.64	107.80	19.15	186.40	43.54	208.60	38.08	195.40	25.15	59.38
Pithecellobium saman	64.20	27.61	34.20	16.42	125.00	31.42	196.20	33.07	170.40	62.92	165.42
Pittosporum phylliraeoides	37.40	5.27	69.00	13.40	104.40	21.01	118.60	22.94	127.20	23.16	240.11

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

Table 4. Mean and standard deviation of stem diameter of the experimental plants in the inland site.

Latin name	Initial		120 DAP		240 DAP		360 DAP		Final	
	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD
Acacia biflora	4.60	0.89	7.20	2.68	Dead	Dead	Dead	Dead	Dead	Dead
Adenium obesum	11.40	1.14	17.33	2.52	20.00	3.46	23.00	1.73	23.33	1.15
Tabebuia rosea	8.60	2.61	14.25	4.35	16.50	4.36	17.00	3.37	17.00	3.37
Pittosporum tobira	8.80	1.48	10.80	2.17	14.80	2.17	16.75	0.96	19.50	3.42
Angophora costata	3.20	0.84	6.20	1.30	Dead	Dead	Dead	Dead	Dead	Dead
Alstonia scholaris	7.60	2.30	9.80	2.95	14.40	2.30	16.33	2.31	16.33	2.31
Thespesia populnea	6.00	5.40	13.40	2.70	15.80	2.39	19.80	1.48	19.80	1.48
Bursaria spinosa	3.00	0.00	5.50	0.58	6.00	0.82	Dead	Dead	Dead	Dead
Callistemon citrinus 'Mauve Mist'	2.60	0.55	4.75	0.50	6.00	0.00	Dead	Dead	Dead	Dead
Callistemon lilacinus	3.80	0.45	7.80	1.64	10.00	2.55	14.60	0.89	14.60	0.89
Callistemon salignus	4.00	0.00	7.20	1.10	8.20	0.84	10.33	0.58	10.33	0.58
Brachychiton acerifolius	8.40	2.61	8.80	0.45	13.20	0.84	13.00	0.00	13.00	0.00
Bambusa vulgaris variegata	2.80	0.45	4.00	0.00	4.50	0.71	Dead	Dead	Dead	Dead
Delonix regia	11.00	0.71	11.80	3.03	15.40	3.36	19.67	1.15	20.00	1.00
Dolichandrone spathacea	7.60	0.89	11.40	3.21	18.50	4.65	25.00	0.00	26.00	0.00
Grevillea robusta	9.00	1.41	14.00	2.35	20.00	5.39	19.00	4.24	21.00	1.41
Hymenosporum flavum	4.60	1.14	9.80	1.30	16.00	2.12	20.50	0.71	22.00	0.00
Jatropha multifida	7.40	0.55	16.00	1.22	23.00	2.00	25.60	2.07	25.60	2.07
Lagerstroemia thorelli	5.00	2.65	7.00	2.12	8.50	3.54	Dead	Dead	Dead	Dead
Lophostemon confertus	4.80	0.84	11.20	1.92	14.50	2.38	18.00	0.00	18.00	0.00
Millingtonia hortensis	10.80	1.30	13.00	1.73	16.80	2.28	24.60	4.77	25.20	4.76
Mimusops elengi	6.00	0.71	9.00	1.41	10.40	1.52	11.33	1.53	11.33	1.53
Peltophorum pterocarpum	8.60	0.89	11.00	1.00	15.40	1.67	19.20	1.48	19.80	1.48
Pithecellobium saman	7.60	1.82	10.20	0.45	13.67	1.53	19.00	0.00	Dead	Dead
Pittosporum phylliraeoides	2.60	0.55	6.60	1.52	12.60	1.52	16.20	2.39	16.40	2.07

DAP=Days after Planting, SD=Standard Deviation.

Table 5. Mean and standard deviation of stem diameter of the experimental plants at the coastal site.

Latin name	Initial		120 DAP		240 DAP		360 DAP		Final	
	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD
Acacia biflora	4.80	1.92	6.60	1.14	9.40	3.29	14.60	4.67	15.40	5.64
Adenium obesum	14.60	2.51	15.60	2.51	23.40	2.05	25.60	1.95	26.60	2.70
Tabebuia rosea	8.60	2.61	11.60	2.61	13.80	4.62	18.00	5.15	19.20	6.02
Pittosporum tobira	6.20	1.10	9.60	1.52	12.20	0.00	14.00	0.00	14.33	0.58
Angophora costata	3.80	0.84	4.60	0.55	7.00	Dead	Dead	Dead	Dead	Dead
Alstonia scholaris	7.20	1.30	9.40	0.89	12.80	27.74	17.00	5.20	17.20	4.97
Thespesia polulnea	7.20	1.79	10.20	1.64	20.20	2.39	27.40	5.46	28.00	4.74
Bursaria spinosa	2.60	0.55	4.20	0.84	5.20	0.00	8.00	0.00	10.00	0.00
Callistemon citrinus 'Mauve Mist'	3.60	0.55	4.40	0.55	4.80	0.84	Dead	Dead	Dead	Dead
Callistemon lilacinus	4.20	0.45	6.20	0.45	10.80	1.00	Dead	Dead	15.00	1.41
Callistemon salignus	4.20	0.45	6.40	0.55	8.20	1.64	14.80	1.10	10.20	1.30
Brachychiton acerifolius	9.80	0.45	9.40	0.55	13.60	Dead	10.00	1.58	Dead	Dead
Bambusa vulgaris variegata	2.20	0.45	2.20	0.45	Dead	Dead	Dead	Dead	Dead	Dead
Delonix regia	12.00	1.87	13.60	1.14	20.40	8.93	36.40	10.43	39.40	12.78
Dolichandrone spathacea	10.40	2.51	12.40	2.07	13.80	3.85	17.00	7.07	17.00	7.07
Grevillea robusta	7.60	0.55	10.20	0.45	15.50	0.00	16.00	0.00	16.00	0.00
Hymenosporum flavum	4.20	0.84	6.20	0.84	8.20	Dead	Dead	Dead	Dead	Dead
Jatropha multifida	14.80	1.92	16.40	1.67	21.80	1.67	24.00	0.71	24.20	1.10
Lagerstroemia thorelli	7.80	1.64	8.60	0.55	11.67	0.71	11.50	0.71	Dead	Dead
Lophostemon confertus	4.60	0.55	7.40	0.89	12.33	0.00	13.00	0.00	Dead	Dead
Millingtonia hortensis	10.80	1.30	12.60	1.52	17.40	4.66	27.60	6.73	27.80	6.42
Mimusops elengi	9.40	1.52	9.80	0.84	10.20	1.00	11.60	1.52	11.60	1.52
Peltophorum pterocarpum	11.00	1.00	11.20	1.30	18.20	2.35	30.80	3.56	30.80	3.56
Pithecellobium saman	8.40	1.34	9.60	0.89	17.80	4.83	29.00	6.08	31.40	8.68
Pittosporum phylliraeoides	3.40	0.55	7.00	1.00	13.40	3.56	18.40	2.51	19.80	2.59

DAP=Days after Planting, SD=Standard Deviation.

Table 6. Mean and standard deviation of canopy of the experimental plants at the inland site.

Latin name	120 DAP		240 DAP		360 DAP		Final	
	Mean (mm)	SD	Mean (mm)	SD	Mean	SD	Mean	SD
Acacia biflora	24.00	5.10	Dead	Dead	Dead	Dead	*Dead*	*Dead*
Adenium obesum	6.00	5.20	19.67	3.79	31.33	10.21	29.67	9.29
Tabebuia rosea	12.50	7.72	6.00	4.90	26.50	8.23	24.75	6.34
Pittosporum tobira	32.80	8.90	45.20	5.02	53.25	4.79	57.50	7.85
Angophora costata	52.00	10.65	Dead	Dead	Dead	Dead	*Dead*	*Dead*
Alstonia scholaris	21.80	5.07	30.80	5.36	59.33	14.36	56.00	8.72
Thespesia populnea	10.00	2.35	34.40	13.94	55.00	17.51	57.80	16.90
Bursaria spinosa	26.00	4.40	23.75	6.90	Dead	Dead	*Dead*	*Dead*
Callistemon citrinus 'Mauve Mist'	23.25	3.20	32.50	2.12	Dead	Dead	*Dead*	*Dead*
Callistemon lilacinus	39.20	9.15	72.20	10.71	88.20	12.93	90.80	20.90
Callistemon salignus	29.80	8.84	42.60	3.85	46.33	6.51	40.67	4.16
Brachychiton acerifolius	34.20	3.19	12.40	11.87	11.00	0.00	16.00	0.00
Bambusa vulgaris variegata	11.80	3.63	31.50	21.92	Dead	Dead	*Dead*	*Dead*
Delonix regia	27.60	15.47	42.00	4.64	42.33	37.29	46.33	35.28
Dolichandrone spathacea	29.20	12.24	43.00	6.83	65.00	0.00	69.00	0.00
Grevillea robusta	38.20	13.97	52.00	8.19	63.00	4.24	68.50	0.71
Hymenosporum flavum	19.60	5.94	19.80	5.40	10.00	2.83	13.00	1.41
Jatropha multifida	19.80	4.97	33.40	4.98	35.60	5.41	41.20	2.39
Lagerstroemia thorelli	6.20	5.85	8.00	8.49	Dead	Dead	Dead	Dead
Lophostemon confertus	25.20	3.03	23.25	4.79	26.00	0.00	27.00	0.00
Millingtonia hortensis	20.60	4.98	46.80	6.98	111.60	18.17	110.00	15.94
Mimusops elengi	16.80	4.15	31.60	6.19	56.33	8.50	58.33	9.02
Peltophorum pterocarpum	14.20	16.74	46.40	11.63	37.40	16.10	38.80	15.55
Pithecellobium saman	7.00	5.10	36.67	12.74	32.00	0.00	Dead	Dead
Pittosporum phylliraeoides	16.80	5.63	26.60	6.50	48.60	14.28	50.00	15.36

DAP=Days after Planting, SD=Standard Deviation.

Table 7. Mean and standard deviation of canopy of the experimental plants at the coastal site.

Latin name	120 DAP		240 DAP		360 DAP		420 DAP	
	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD
Acacia biflora	36.80	15.97	47.60	16.16	92.60	13.35	99.20	14.18
Adenium obesum	13.00	2.83	18.00	2.00	28.60	7.20	28.40	3.13
Tabebuia rosea	23.80	7.43	20.40	10.01	44.80	13.57	39.60	16.07
Pittosporum tobira	32.40	6.58	47.40	7.67	78.33	10.50	63.00	11.27
Angophora costata	36.20	5.89	48.00	0.00	Dead	Dead	Dead	Dead
Alstonia scholaris	21.60	6.69	33.40	6.19	48.20	11.45	49.60	9.91
Thespesia polulnea	11.20	2.68	41.80	3.96	69.80	12.72	68.80	7.79
Bursaria spinosa	10.80	3.42	19.00	9.95	29.00	0.00	31.00	0.00
Callistemon citrinus 'Mauve Mist'	46.80	3.96	35.60	10.31	Dead	Dead	Dead	Dead
Callistemon lilacinus	16.40	2.88	82.40	8.79	Dead	Dead	105.00	8.28
Callistemon salignus	41.20	1.64	54.80	10.94	102.60	7.70	29.80	11.17
Brachychiton acerifolius	34.00	2.92	2.00	0.00	39.40	17.69	Dead	Dead
Bambusa vulgaris variegata	11.00	3.87	Dead	Dead	Dead	Dead	Dead	Dead
Delonix regia	29.40	8.96	66.80	15.45	148.80	33.15	135.40	36.31
Dolichandrone spathacea	17.00	7.11	20.60	11.48	4.00	0.00	6.00	2.83
Grevillea robusta	46.60	4.56	51.50	1.91	48.00	0.00	43.00	0.00
Hymenosporum flavum	26.40	7.64	19.40	10.04	Dead	Dead	Dead	Dead
Jatropha multifida	15.80	7.95	38.40	6.58	43.00	6.82	28.00	6.60
Lagerstroemia thorelli	16.40	9.45	44.00	16.82	21.50	4.95	Dead	Dead
Lophostemon confertus	41.00	3.32	34.67	6.11	24.00	0.00	Dead	Dead
Millingtonia hortensis	22.80	4.44	54.80	11.30	143.60	43.32	142.80	37.25
Mimusops elengi	27.80	5.63	42.60	13.18	76.40	9.91	77.80	9.26
Peltophorum pterocarpum	38.60	2.30	70.20	9.18	111.00	20.19	96.80	24.67
Pithecellobium saman	8.80	7.50	41.20	7.95	94.40	24.05	88.00	43.85
Pittosporum phylliraeoides	28.60	7.77	40.40	7.86	70.00	24.17	74.80	21.53

DAP=Days after Planting, SD=Standard Deviation.

Table 8. Effect of high temperature on the growth of the experimental trees.

Plant species	Effects of temperature
Acacia biflora	Reduced growth. Drying of leaves from the topside.
Adenium obesum	Good growth was noticed. Old as well as new leaves are fleshy and healthy. More number of flowers is still on the plant. No drying of leaves. Peeling of outer sheath gives the plant a new look.
Tabebuia rosea	No noticed growth. The leaves show yellowing and loss of vigor. Shedding of leaves noticed.
Pittosporum tobira	Plants turn to coppery brown. Complete drying of leaves noticed.
Angophora costata	Complete drying of stem as well as the leaves. Total loss.
Alstonia scholaris	Good growth. Even though there is no marked increase in the height of the plant (main stem), vigorous growth was noticed from the side branches. More production of side branches.
Thespesia populnea	Drying of leaves from the middle portion of the plant. Drying of all leaves and they are seen hanging on the plant. The stem shows burned brown patches, which on later stages turn to black. Yellowing also.
Bursaria spinosa	Plants have no prominent growth. Drying of leaves and stem starts from tip downwards. There is no substantial elongation of branches.
Callistemon citrinus ' Mauve Mist'	Top leaves dried. Stems are also showing symptoms of dryness. No more new branches.
Callistemon lilacinus	No effect of heat. Increased production of branches. Elongation of inter-nodal region leads to extended growth of branches. Sub branching of main branches at the tip was noticed.
Callistemon salignus	Leaves on the upper portion had dried. Drying starts from margin of leaves and on later stages complete drying of leaves. Curving of leaves was noticed.
Brachychiton acerifolius	Complete shedding of leaves, but the stem remains healthy and green. Petioles are still on the plant.
Bambusa vulgaris variegata	Total loss.
Delonix regia	Good growth. The leaves in the lower part of the plant show yellowing symptoms. Sometimes drying of these leaves, leaving only the petioles. New green fleshes are coming. More branches from the base.
Dolichandrone spathacea	No growth. The leaves start drying from the margin. Leaves shows yellowing which on later stage lead to complete drying of branches.
Grevillea robusta	Burning of the top leaves. The leaves first turn to pale green and became dark on later stages. The stem became very hot on extreme hot conditions, which can be felt by touching the stem.
Hymenosporum flavum	The leaves were totally dried. Black patches were observed on the stem. These patches coalesce to form bigger patches, which ultimately lead to drying of stem.
Jatropha multifida	The entire leaves dried but the leaf petiole remained on the plant. Drying starts from leaf margins. The dried leaves were seen hanging in the plant. Exudation of gum from the plant leads to darkening on the collar region.
Lagerstroemia thorelli	Shedding of the leaves and the flowers. Leaves first turns copper brown and then shedding occurred.
Millingtonia hortensis	Healthy vigorous growth. New branches were formed from the middle of the plant. Lush green new branches and leaves.
Mimusops elengi	Good growth. Healthy new fleshes are coming. No change in the color of the leaves. But no increase in height of the plant.
Peltophorum pterocarpum	Excellent growth. The trunk was well developed and has prominent color of copper brown.
Pithecellobium saman	Good growth. The leaf margins show yellowing. More branches from the bottom part of the plant. Increase in height was noticed.
Pittosporum phylliraeoides	Leaf tips were dried. Good growth was noticed. From middle part of plant numerous branches are coming and are having good growth. Lush green color of leaves.

Table 9. Effect of low temperature on the growth of the experimental trees.

Plant species	Effects of temperature
Acacia biflora	Good growth. Flowering was seen in almost all plants. No drying of leaves. Elongation and subsequent growth of lateral branches produced a wide canopy. At the beginning of the winter the entire leaves were shredded.
Adenium obesum	All the leaves showed burned appearance. New leaves were seen to be shredding. Stem and branches remained healthy. New flushes along with flower buds were coming.
Tabebuia rosea	The drying of the leaves started from margins, which spread to the center of the lamina. The leaves showed yellowing. Almost stunted growth.
Pittosporum tobira	Good growth. The branches spread to more area with good shiny lusty green which gave the plant a bushy appearance.
Angophora costata	Total loss due to high temperature in summer.
Alstonia scholaris	Almost retarded growth. With the onset of winter season, shredding of leaves started. Healthy young leaves were produced from the apical growing tip. Branching of the plant was noticed from the base.
Thespesia populnea	Excellent growth. From the entire region of the plant new branches came with fully developed leaves. Well developed trunk.
Bursaria spinosa	No prominent growth. Drying of the branches from the tip was noticed.
Callistemon citrinus ' Mauve Mist'	Total loss of plants due to high temperature in summer.
Callistemon lilacinus	No effect of cold. Additional branches were produced which grew much longer than the main stem. Sub-branching was noticed. The leaves become more greenish.
Callistemon salignus	Drying of the stem and leaves. It started from the margins and on later stages spread to the entire leaf area eventually lead to the total drying and shredding of leaves. Since the stem was drying the height of plant was reduced considerably.
Brachychiton acerifolius	Total loss due to high temperature in summer.
Bambusa vulgaris variegata	Total loss.
Delonix regia	Excellent growth. Trunks were well developed. The plants started shredding the leaves from the onset of the season and now the plants have no leaves, which gave the plant a skeletal appearance.
Dolichandrone spathacea	No prominent growth. The stem dried from the tip downwards, so height was reduced. Due to drying and shredding there were no leaves on the stem. But the stem remained healthy.
Grevillea robusta	When compared to the growth in summer the growth in the winter season was very good. New branches and flushes were coming.
Hymenosporum flavum	Total loss of plants due to high temperature in summer.
Jatropha multifida	No prominent growth. More branches were produced from the base. The leaves were dried and seen hanging from the plant. The increase in girth in the collar region was noticed.
Lagerstroemia thorelli	Even though the plants flowered in late summer, leaves and stem were dried out in the cold season.
Millingtonia hortensis	Drying was seen only on margins of leaves. Trunk was well developed. Plants were flowered at the beginning of the season.
Mimusops elengi	Excellent growth. Good development of canopy was noticed, but no increase in stem thickness. Healthy green leaves.
Peltophorum pterocarpum	Normal growth. The leaves were dried and shredded from the plants. New sprouts were coming from the stem axils.
Pithecellobium saman	All the plants lost vigor. Stems on the upper part were dried. The leaves were firstly turned to yellow and on later stages complete drying was the result. The dried leaves were seen hanging from the stem.
Pittosporum phylliraeoides	Very good growth. No effect on the growth and development of the plant. More branches were coming from the entire stem.