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

Plant enrichment in the desert ecosystem

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Received 18 December 2006, accepted 22 March 2006.

Abstract

Although the local weather conditions are harsh, Kuwait has a unique desert ecosystem. However, many of Kuwait's native plants are threatened, endangered or difficult to germinate in extreme weather conditions. Native plants are the main constituent of the biological diversity. They are also highly adapted to the local environmental and climatic conditions. Therefore, native plant conservation can restore the vegetation cover in Kuwait's desert. A study was executed in Kuwait's desert to develop the appropriate plant palette, to provide selected native and acclimatized plants to enhance the microclimate and periodically assess the status of native flora and fauna at the site. Approximately 2240 acclimatized native and naturalized plants and mangrove seedlings in addition to a desert-seed mix were used for planting at the project site. The growth and development of these plants were monitored routinely, and the initial results were encouraging. Soil and water samples were routinely collected and analyzed for various parameters. The study results suggest that the micro-climate of the site has improved with the agricultural activities occurring at the site, where 12 native plant species and 35 native and migratory birds were observed at the time of the project termination.

Key words: Biodiversity conservation, native plant restoration, sustainable greenery development, desert development.

Introduction

The climate of Kuwait is characterized by very hot, dry summers and cool rainy winters. Extremely high temperatures and prolonged heat waves can damage agricultural production, increase energy and water consumption and also badly affect human well being [10, 14, 17]. Although Kuwait has harsh climatic conditions and limited water resources, it has a unique desert ecosystem, comprising of 374 plants, 28 mammalian fauna, over 300 bird and 40 reptilian species [23]. However, Kuwait is suffering from severe land degradation with grave consequences for the natural vegetation, plant biodiversity and sustainable development of natural resources. In fact, land degradation and desertification are major menaces in several regions of the world with serious implications for sustainable development of natural environment [7]. Studies on the response of global climate system to smoke from burning oil wells in Kuwait showed a decrease in surface air temperature of approximately 4°C in the Gulf region [5].

There is increasing concern in Kuwait regarding the frequent occurrences of harsh climate conditions with summer air temperature exceeding the 50°C mark. Al-Fahed *et al.* [3] reported that warming trend in climate is partly due to global climate change and the rest caused by urbanization. According to Nasrallah *et al.* [12] atmospheric carbon dioxide concentration is the highest in February and lowest in September reflecting the growth and decay of vegetation in Kuwait during this period. Along with typical summer conditions that affect Kuwait, the shift of the Subtropical Jet Stream northward and the build up of a ridge of high pressure in the 500 hPa level play a major role in heat wave events during the summer season in Kuwait [11]. Kuwait has suffered severely from the effects of desertification in recent years, due to harsh climatic conditions, increased human pressure, overgrazing and Gulf war activities [24]. The land degradation is exacerbated by the inherent fragility of soils and loss of native vegetation cover in the Kuwaiti desert [4, 8, 15]. Many native plants of Kuwait and the Arabian Peninsula are threatened, endangered or difficult to propagate. Conservation and mass propagation of native plants can play an important role in the rehabilitation of Kuwait's desert [1, 2]. Tissue culture technology can be utilized for the conservation and mass propagation of selected native plants [28].

Native plants are the key components of the global biological diversity, and are highly adapted to the local environmental and climatic conditions. Native plants can potentially aid conservation by contributing to genetic diversity and buffering small and otherwise isolated populations from extinction [26]. Furthermore, native plants provide highly effective mix for revegetation projects and reduce the potential for negative ecological consequences [29]. Native plant communities provide a healthy environment and help preserve the ecological balance and perpetuate the relationship between the native plants and the many other organisms that depend upon them for their survival. They also provide food and shelter to numerous insects, birds and animals. Conserving biological diversity in arid regions infers deliberate human action to preserve the diversity of the natural environment in a sub-sample of the globe that has special characteristics.

Since the 1970's, KISR has undertaken several investigations on the characterization of desert ecosystems, rangeland management, soil and vegetation surveys and assessment of negative impact of Iraqi aggression on soil and ecosystem. Findings of these studies provided valuable input for executing this project [21-23, 25, 31]. The aim of our study executed in Kuwait's desert was to develop the appropriate plant palette, to provide selected native and acclimatized plants to enhance the microclimate and periodically to assess the status of native flora and fauna at the site.

Material and Methods

The experimental site was located in a depression area of an oil field. The soil in the area is shallow due to the presence of "*gatch*" layer near to the surface, calcareous in nature and sandy in texture.

Approximately 2200 plants of native, acclimatized and marine plant species including 100 mangrove seedlings were planted (Table 1). Most of these plants were planted in fall 2005, where the site and plant specifications were matched. Since supplemental irrigation was provided to these plants, a favorable soil moisture regime was created, which allowed the germination of dormant and newly dispersed native seeds and establishment early in the season, thus improving the chances for their recovery.

Table 1. Plant species planted for the establishment of the site.

Serial No.	Scientific name	Arabic and Common Name	Family	Habit	Plant No.	Soil requirement	Irrigation requirements	Origin	Remarks
1.	*Helianthemum lippii*	رقروق Rakrouk	Cistaceae	Shrub	200	Native soil	Irrigation upon plantation, followed by weekly irrigations until first rain. No supplemental irrigation needed afterwards.	Kuwait	Two meter triangular spacing
2.	*Farsetia aegyptia*	الباانة Allabana	Cruciferae	Shrub	200	Native soil	Irrigation upon plantation, followed by weekly irrigations until first rain. No supplemental irrigation needed afterwards.	Kuwait	Two meter triangular spacing
3.	*Rhanterium eppaposum*	عرفج Arfaj	Compositae	Shrub	200	Native soil	Irrigation upon plantation, followed by weekly irrigations until first rain. No supplemental irrigation needed afterwards.	Kuwait	Two meter triangular spacing
4.	*Pennisetum divisum*	ثمام Thammam	Gramineae	Grass	200	Native soil	Irrigation upon plantation, followed by weekly irrigations until first rain. No supplemental irrigation needed afterwards.	Kuwait	Two meter triangular spacing
5.	*Calligonum polygonoides*	أرطة Arta	Polygonaceae	Shrub	200	Native soil	Irrigation upon plantation, followed by weekly irrigations until first rain. No supplemental irrigation needed afterwards.	Kuwait	Two meter triangular spacing
6.	*Prosopis cineraria*	غاف Gaf	Leguminosae	Tree	50	Agricultural soil	Irrigation upon plantation, followed by supplemental irrigation for one year.	Arabian Gulf	Six meter triangular spacing
7.	*Ebanopsis ebano*	Texas Ebony	Mimosaceae	Tree	7	Agricultural soil	Irrigation upon plantation, followed by supplemental irrigation for one year.	Texas/ USA	Six meter triangular spacing
8.	*Lysiloma watsonii*	Desert Fern	Fabaceae	Tree	7	Agricultural soil	Irrigation upon plantation, followed by supplemental irrigation for one year.	Southwest USA	Six meter triangular spacing
9.	*Havardia mexicana*	Mexican Ebony	Fabaceae	Tree	7	Agricultural soil	Irrigation upon plantation, followed by supplemental irrigation for one year.	Southwest USA	Six meter triangular spacing
10.	*Tephrosia haussknechtii*	Goat's Rue	Fabaceae	Shrub	16	Agricultural soil	Irrigation upon plantation, followed by supplemental irrigation until establishment.	Asia	Two meter triangular spacing
11.	*Parkinsonia praecox*	Sonoran Palo Verde	Fabaceae	Tree	4	Agricultural soil	Irrigation upon plantation, followed by supplemental irrigation for one year.	Sonoran Desert	Six meter triangular spacing
12.	Desert Seed Mix[x]			Ground Cover	~10 kg	Agricultural soil	See specifications		See specificatio

Total Number of Plants = 2141. [x] The desert seed mix was formulated by mixing seeds of six species namely *Eragrostis curvula, Ambrosia chamissionis, Artemisia californica, Lasthenia glabrata, Mimulus aurantiacus* and *Limonium californicu.*

A desert seed mix (Table 1) was sown to enhance the micro-climate and to facilitate the germination and establishment of native plants at the oasis site. Approximately 30-40 cm of soil was excavated and replaced by agricultural soil, followed by light compaction pre and past sowing. The seed mix was lightly covered by a mesh to protect the seeds from winds and insects. Supplemental irrigation was not administered for the seed mix and relied totally on the rainfall to germinate and establish. Seed germination was calculated subjectively, and it was estimated to be 50% germination. The germinated species are expected to reseed once the weather conditions become favorable.

The irrigation of trees and shrubs is shown in Table 2. Five replicates of each plant species were identified to assess the survival and growth performance under the desert conditions. Plant height and canopy were recorded at monthly intervals. Routine monthly data on growth performance and survival were recorded to determine their growth rates and their effects on the recovery of native plants and wildlife habitats of the site.

Table 2. Water required (mm per day) [16].

Plant type	Average daily demand	Peak daily demand
Trees	15.0	20.0
Shrubs	4.0	10.0

Results and Discussion

The plants were performing well considering the site conditions were their survival rate was high until the termination of the project. The desert mix seeds recorded approximately 50% germination (subjective reading). The seed-mix is expected to re-seed once the weather conditions are favorable.

The average values for height and canopy and final survival are presented in Tables 3 and 4. Except for *Rhanterium epapposum* and *Tephrosia haussknechtii* all species established very well and showed more than 80% survival during the first 120 days after planting (DAP). However, the relative growth rate was the highest (113.16%) in *Pennisetum divisum* followed by *Calligonum polygonoides* (67.76%), *Farsetia aegyptia* (51.46%), *Helianthemum lippii* (30.05%), *Tephrosia haussknechtii* (12.81%), *Prosopis juliflora* (7.86) and *Prosopis spicigera* (6.86%). In contrast, *Zizyphus spina christi* had the least growth rate (4.88%) during this period. However, it is important to note that species like *Helianthemum lippii* have spreading type of growth and hence, had lower height growth rates.

Pennisetum divisum had the highest (100.20 cm) canopy followed by *Helianthemum lippii* (63.30 cm) (Table 4). *Tephrosia haussknechtii* had the least (17.00 cm) canopy 120 days after planting. Since plant canopy is dependent on growth habit of a given species, it is inappropriate to make comparisons among different species. However, both height and canopy growth parameters provide only a general idea about the growth habit and the likely impact a particular species might have in a natural oasis setting.

Routinely soil and water samples were collected from the study site and chemically analyzed for various parameters, including nutrients and heavy metal content. Results proved insignificant amounts of heavy metals in the samples. However, it was recommended that slow-release fertilizers be applied to the tree and shrub seedlings in the growing seasons to fortify the soil with the essential nutrients. Irrigation should occur daily in the

Table 3. Average periodic plant height (cm) of different native and naturalized plants at the site.

Plant species	Initial		30 DAP		60 DAP		90 DAP		120 DAP		Growth rate (%)	Plant survival (%)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Pennisetum divisum	53.2	7.15	27.66	3.61	63.60	5.32	81.90	11.55	113.40	7.86	113.16	100
Calligonum polygonoides	25.5	5.38	11.80	4.94	30.22	5.95	36.89	6.66	42.78	6.02	67.76	90
Rhanterium eppaposum	6.5	2.99	12.38	6.55	20.50	6.44	30.00	6.82	Dead	Dead	Dead	0
Farsetia aegyptia	20.6	4.90	21.30	3.33	23.30	3.50	28.10	3.70	31.20	5.14	51.46	100
Helianthemum lippii	39.6	9.07	40.40	7.24	42.10	5.90	43.40	5.74	51.50	12.23	30.05	100
Tephrosia haussknechtii	35.9	8.52	38.20	10.64	39.30	11.39	37.00	2.94	40.50	5.45	12.81	40
Prosopis spicigera	67.2	14.21	70.60	14.03	73.80	15.67	70.70	13.88	71.88	14.20	6.96	80
Zizyphus spina christi	108.5	26.20	111.90	26.79	115.60	28.08	114.50	24.49	113.80	25.44	4.88	100
Prosopis juliflora	108.1	16.49	109.60	16.69	112.50	14.21	104.70	22.48	116.60	19.08	7.86	100

DAP= Days after Planting; SD= Standard Deviation

Table 4. Average periodic plant canopy (cm) of different native and naturalized plants at the site.

Plant species	Initial		30 DAP		60 DAP		90 DAP		120 DAP	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pennisetum divisum	95.90	21.24	49.84	10.98	113.30	22.83	108.40	11.23	100.20	10.51
Calligonum polygonoides	38.00	12.29	17.90	8.92	43.44	13.23	28.78	8.04	41.11	11.10
Rhanterium eppaposum	15.00	6.31	18.88	11.14	26.33	8.55	26.40	12.28	Dead	Dead
Farsetia aegyptia	34.90	6.87	38.80	5.31	42.40	4.65	46.70	7.13	40.90	10.09
Helianthemum lippii	52.00	11.31	52.00	12.68	56.70	13.00	49.00	9.78	63.30	13.66
Tephrosia haussknechtii	24.40	3.98	26.60	8.69	27.00	9.07	21.25	6.18	17.00	2.58
Prosopis spicigera	44.50	8.38	41.80	7.54	44.50	10.24	-	-	-	-

DAP= Days After Planting, SD= Standard Deviation.

summer season using the drip system; followed by twice weekly in the winter using the plant's recommended water demands.

The micro-climate of the site was improved drastically since summer 2005; as the agricultural activity at the site improved the soil conditions. The water used for irrigation has loosened the compacted soil thus allowing native dispersed seeds to germinate and develop. Approximately 13 native plant species (Table 5) and 35 native and migratory birds (Table 6) were observed at the site till the termination of the project.

Table 5. Native plants that grew naturally at the site.

Serial No.	Native plant species
1.	*Chenopodium murale*
2.	*Filago pyramidata*
3.	*Cutandia memphitica*
4.	*Salsola imbricata*
5.	*Moltkiopsis ciliate*
6.	*Phragmites australis*
7.	*Reseda arabica*
8.	*Rostraria pumila*
9.	*Senecio glaucus*
10.	*Silene villosa*
11.	*Sisymbrium irio*
12.	*Tamarix aucheriana*

Table 6. Birds observed at the site in March 2006.

S.No.	Species	No.	Remarks
1.	*Circaetus gallicus*	1	Migratory
2.	*Circus cyaneus*	1	Migratory
3.	*Coturnix coturnix*	1	Migratory
4.	*Himantopus himantopus*	14	Passage migrant
5.	*Charadius alexandrinus*	3	Two chicks and mom resident
6.	*Streptopelia decaoto*	18	Resident
7.	*Streptopelia sengalensis*	6	Resident
8.	*Oena capensis*	4	Resident
9.	*Apus melba*	22	Passage migrant
10.	*Apus pallidus*	8	Passage migrant
11.	*Upupa epops*	5	Passage migrant
12.	*Galerida cristata*	12	Resident
13.	*Eremopterix nigriceps*	4	Resident
14.	*Calandrella brachydactyla*	25	Passage migrant
15.	*Riparia riparia*	25	Passage migrant
16.	*Hirundo rustica*	6	Passage migrant
17.	*Anthus campestris*	2	Passage migrant
18.	*Motacilla alba*	8	Passage migrant
19.	*Pycnonotus leucogenys*	3	Resident
20.	*Prunella atrogularis*	1	Vagrant
21.	*Phoenicurus phoenicurus*	2	Passage migrant
22.	*Oenanthe oenanthe*	2	Passage migrant
23.	*Oenanthe isabellina*	6	Passage migrant
24.	*Oenanthe pleschanka*	4	Passage migrant
25.	*Oenanthe hispanica*	1	Passage migrant
26.	*Acrocephalus schoenobaenus*	7	Passage migrant
27.	*Phylloscopus collybitta*	2	Passage migrant
28.	*Fecedula semitorquata*	3	Passage migrant
29.	*Lanius isabellinus*	9	Passage migrant
30.	*Lanius senator*	2	Passage migrant
31.	*Lanius nubicus*	1	Passage migrant
32.	*Passer domesticus*	80	Resident and nesting on date palms
33.	*Anax parthenope*		Plenty are hovering over the lake
34.	*Crocothemis erythraea*		Plenty hovering over the lake
35.	*Utetheisa pulchella*	12	Only few were observed

Acknowledgement

The project team would like to thank the Kuwait Oil Company for their financial support of the study; as well as the management of the Kuwait Institute for Scientific Research for their continued support and interest in the project.

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