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Restoration of mangrove vegetation at Red Sea coast, Saudi Arabia

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An attempt was carried out to restore mangrove forests as coastal bioshield at the shoreline of Al-Sharifa Island, Al-Lith, Red Sea. Healthy saplings of grey mangrove, *Avicennia marina* were grown in the Biosaline agriculture centre of National aquaculture group (Naqua) at Al-Lith, Jeddah. Six month old mangrove saplings (25000) were planted at 11 locations of Al-Sharifa Island in Al-Lith village where mangrove vegetation was found sparse and destroyed by natural disasters. A survey conducted after 2 years showed that saplings planted along the shoreline of south and north lagoon of the island achieved 39% survival and were able to tolerate salinity up to 70 ppt. Causes of mortality were siltation, changes in topography, drying up of lagoon, accumulation of debris, and competition and destruction by crabs. The grey mangrove, *Avicennia marina* is a salt tolerant variety and is ideal for mangrove afforestation program at Red Sea coast.

[Keywords: *Avicennia marina*; Coastal bio-shield; Mangrove restoration; Surveillance]

Introduction

Nature has provided biological mechanisms for protecting coastal communities from the fury of cyclones, coastal storms, tidal waves and tsunamis[1]. Mangrove forests constitute one such mechanism for safeguarding the ecological security of the coastal areas and the livelihood of fisher and farm families living in the coastal zone[2,3]. This ecological, economic and social value will further increase, if a rise in sea level taken place as a result of global warming and the melting of glaciers and the Arctic and Antarctic ice caps[4]. Mangroves are an important part of any coastline and helps in maintaining the biodiversity of the area in addition to adding to physical protection by acting as a bio-shield to fragile coastal areas [5-7]. The grey mangrove, *Avicennia marina* (Forsk.) (Family: *Vernemaceae*) enjoy a wide distribution and is found in the Arabian Peninsula along the coast of Egypt, the shores of Red Sea and in inter tidal areas of Arabian Gulf [8]. In Saudi Arabia, majority of mangrove forests are found on the eastern coast of Red Sea between Jizan in the south and Dibain in the north while on the Gulf coast they are limited to Dammam area. It is widespread along the Red Sea in areas such as Al Darb, Al Raqabah, Al Qahmah, Wadi Dhahaban, Rabigh area in Jeddah, Jizan and Farasan Island.

Realizing the need for protecting mangrove areas in the island and coastal areas of lagoon at Al-Lith village, a mangrove afforestation program was initiated by National Aquaculture Group (NAQUA) as part of a larger project on Biosaline agriculture in consultation with International Centre for Biosaline Agriculture, Dubai, UAE. The aim of the project was to increase the mangrove vegetation in the aquaculture project zone by restoring the mangrove at coastal shoreline of Al-Sharifa Island.

Materials and Methods

A survey was conducted at the lagoon area of Al-Sharifa Island where mangroves were found to be sparse and meager. Based on destruction of mangrove due to environmental factors, eight stations in South lagoon and three stations in North lagoon were identified. Details on various sites selected for mangrove restoration are shown in Figures 1 and 2. Seeds of *Avicennia marina* were collected from trees at lagoon side during March-April months and brought them to rearing and nursery center at Biosaline Agriculture Project (BIOSAP) for sapling production. Seeds which showed leafhopper attack were dipped in a systemic insecticide, Imidor 200SL (Astra Agricultural Co., Ltd., KSA) at a concentration of 3 ppm for 30 minutes before seeding. Black plastic agricultural bags (10 cm in diameter and 20 cm height with holes) containing mixture of sand and peat moss in the ratio 1:1 was prepared for seeding and stacked

Fig. 1 — Site selected for planting at South Lagoon

Fig. 2 — Site selected for planting at North Lagoon

as rows in concrete tanks. One-fourth of seed was inserted into sand and allowed to germinate under shade for 15-20 days. After germination, seedlings were acclimatized to seawater gradually by exposing them to saline water from 5ppt to 40ppt with an increment of 5 ppt/week. Salinity was measured by using a refractometer (Atago Co. Ltd., Japan). When they were fully acclimatized to 40 ppt sea water, saplings were transferred to nursery tanks (7m x 6m, height 30 cm) containing sea water. After rearing for six months in shade house, saplings were hauled to the lagoon on a truck and were kept in a temporary nursery for two weeks to acclimatize in seawater. For sapling planting, pit was dug at a depth of 20 cm and planting was done as one sapling/pit along the shoreline randomly at a distance of 3 meters between each other. Plastic cover of sapling was removed and they were planted as groups in shallow areas and shoreline. After planting, location of all pits were marked with GPS (GPSMAP 60 CSx, GARMIN, Taiwan) and total saplings planted were recorded (Table 1).

Growth of mangrove was assessed by measuring the height of saplings every year. Survival (%) was calculated as: number of plants available during survey/ total number of saplings planted x 100. In each survey, biotic and abiotic factors (siltation, changes in topography, drying up of lagoon, accumulation of

Table 1 — Details of locations and saplings planted

Site	Location (GPS)	Saplings (#)
South Lagoon		
1	N 20°15'01.4" E 040° 00'41.7" N 20°14'56.8" E 040° 00'47.7"	3000
2	N 20°14'56.8" E 040° 00'47.7" N 20°14'46.8" E 040° 01'07.2"	3000
3	N 20°14'29.8" E 040° 01'21.6" N 20°14'37.0" E 040° 01'32.1"	3000
4	N 20°14'35.9" E 040° 02'35.2" N 20°14'35.1" E 040° 01'46.7"	3000
5	N 20°14'31.3" E 040° 02'08.3" N 20°14'27.6" E 040° 02'20.0"	1500
6	N 20°14'27.6" E 040° 02'20.0" N 20°14'28.2" E 040° 02'24.2"	1500
7	N 20°14'28.2" E 040° 02'24.2" N 20°14'28.5" E 040° 02'27.7"	2000
8	N 20°14'27.7" E 040° 02'28.2" N 20°14'28.4" E 040° 02'31.9"	2000
North Lagoon		
1	N 20° 7'24.4" E039° 54'45.1"	2000
2	N 20° 16'59.0" E039° 55'38.7"	2000
3	N 20° 16'07.8" E039° 56'44.5"	2000
Total		25,000

debris, competition and destruction by crabs) affecting mortality were considered and recorded. Details of nursery rearing, transportation, planting and growth assessment are shown in Figure 3.

Results

Result on mangrove survey conducted at North and South lagoon is presented in Table 2. After 2 years, high survival (52.1 %) was recorded at site 5 and low (26.2 %) at site 6 in South lagoon. Whereas, in North lagoon, highest survival (39.0 %) was recorded at site 2 and lowest (33.1 %) at site 1. Causes for mortality were due to siltation, changes in topography, drying up of lagoon, accumulation of debris, and competition and destruction by crabs. Algal deposition was noticed at site 5 and 7 in South lagoon. Many saplings were found dried at site 8 due to lack of water. Accumulation of plastic bags, empty cans, and broken fishnets were noticed at site 3 and 4 due to anthropogenic activities.

Discussion

Restoration of mangroves has received a lot of attention worldwide for several reasons. Firstly, the long ignored ecological and environmental values of mangrove forests have been documented for many mangrove areas [9,10]. Secondly, there is a subsistence dependence on natural resources from mangrove forests[11]. In addition, large losses of mangroves have occurred throughout the world leading to coastal erosion, decline of fishery resources and other environmental consequences, some of which is in need of urgent attention[12]. Restoration provides an opportunity to improve or enhance the landscape and increase environmental quality. Mangrove afforestation program is being taken up at a large scale in Bangladesh, India and Vietnam principally to provide protection in typhoon-prone areas as well as to generate economic benefits to the poor coastal communities[13-15]. According to Saenger and Siddique, a semi-intensive shrimp farm requires a mangrove area that is 35-190 times larger than the surface area of the pond[13].

The result of the study shows that grey mangrove, *A. marina* thrive well at the coastal shore of Al Sharifa island even after 2 years of planting. Trees were found to be healthy and growing well at high saline conditions (70 ppt). Vyas and Sengupta reported that mangrove like *Avicennia officinalis* grows well in the marshy land of Sundarbans, India where an inflow of fresh water occurs during monsoon and plants attain a height of 6 meters from natural seedlings[15]. Mukherjee *et al.* reported that *Ceriops decandra, Ceriops tagal, Excoecaria agallocha, Rhizophora apiculata* and *Xylocarpus mekongensis* are slow growing plants suitable for afforestation program at estuaries and low saline areas[14]. The slow growth rate of *A. marina* planted at lagoon coast may be due to the high saline condition of lagoon water due to evaporation and lack of tidal inflow into the lagoon.

In mangrove afforestation program, seedlings are produced by natural and artificial ways. Natural production includes the collection of sapling from mangrove habitats and its maintenance in selected areas adjoining to the habitat where tidal action seems to be less. Further, seedlings are reared in shallow area until it reaches the size for planting. Artificial production includes the collection of seeds from mangrove trees during the season and its propagation by careful rearing in controlled nursery conditions. The advantage of nursery saplings compared to wild sapling is the higher survival rate (80–100%) after 24months of planting[16]. For mangrove afforestation program, an artificial production of seedlings was

Fig. 3 — Stages of mangrove rearing and growth recording, 1. Rearing sapling in green house; 2. Transferring six month old saplings for planting; 3. Transportation of saplings to site; 4. Planting saplings; 5. Recording growth and survival; 6. Grown up mangroves after 2 years

followed in the present study. A suitable methodology was standardized for acclimatizing seedlings in sea water and for the production of grey mangrove, *A. marina* seedlings.

When contemplating mangrove rehabilitation, special attention must be paid to seed availability, site elevation, spacing of planting, salinity and fresh water runoff, flooding, wave and tidal actions, weed eradication, nursery techniques, monitoring, community participation and total cost of restoration measures[17,18]. The survival rate of trees along the north lagoon coast shows that mangrove could grow even at high saline water (70 ppt) and this indicates *A. marina* could tolerate high saline conditions of Red Sea coasts. Survey results show that an average 39 % of mangrove is growing healthy in the coastal area of Al Sharifa Island which indicates that seedlings were well adapted and acquainted with the existing mangrove ecosystem of the area.

Table 2 — Survey result of mangrove trees

Location	1st year		2nd year	
South Lagoon	Survival (%)	Height (cm)	Survival (%)	Height (cm)
1	60.2	80±21	40.1	13±32
2	75.8	86±24	38.7	148±26
3	55.3	88±13	40.1	210±35
4	70.9	76±23	40.2	176±28
5	81.2	60±28	52.1	152±39
6	55.2	67±20	26.2	160±26
7	66.9	86±12	33.2	214±42
8	71.4	77±33	40.4	201±21
North Lagoon				
1	45.3	60±21	33.1	112±28
2	65.3	65±16	39.0	146±18
3	70.9	62±19	36.5	138±27
Average	65.3	73±18	38.1	162±31

The mangrove ecosystem is a complex one. It is composed of various inter-related elements in the land sea interface zone which is linked with other natural systems of the coastal region such as corals, sea grass, coastal fisheries and beach vegetation[19]. The mangrove ecosystem consists of water, muddy soil, trees, shrubs and their associated flora, fauna and microbes[16]. It is a very productive ecosystem sustaining various forms of life. Waters near mangrove areas are nursery grounds for fish, crustacean and mollusc and also provide habitat for a wide range of aquatic life, while the land supports a rich and diverse flora and fauna. It also influences the micro climate, prevents coastal erosion, enhances accretion and combats natural calamities such as cyclones and tidal bores[20-21].

Conclusion

The effort carried out to restore mangrove ecosystem at the shoreline of Al Lith was based on a strategy to conserve the existing ecosystem at the coastal belt. It is expected that the present afforestation and restoration program carried out would help to sustain the natural mangrove vegetation at Red Sea coast.

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