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AN ASSESSMENT OF THE USE OF *AVICENNIA MARINA* FORSK VIERH. TO RECLAIM WATERLOGGED AND SALINE AGRICULTURAL LAND

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Abstract

Mangroves are woody plants that grow in tropical and sub tropical areas. The mangroves can exist under wide range of salinity, tidal amplitude, wind and temperature, even in muddy and anaerobic soil condition. An experiment was conducted in the University Campus to know the establishment, survival and growth of seedlings of *Avicennia marina* based on planting observations in water logged and saline silty loam of Karachi. Growth and physiological responses were recorded at seedlings stages. The area of seeds, height, number of leaves, area of leaves and number of pneumatophores were recorded. Physical and chemical analyses of soil and water were also carried out in order to get better information. The result showed that due to availability of oxygen, mangroves did not hold up complexity to respire that's why could not exhibit pneumatophores. It is suggested that those areas which are fully saline and waterlogged and unable to support any other crop can be conserved by planting mangroves.

Introduction

Agriculture plays a pivotal role in the economy of Pakistan. The country has an arid and semi-arid climate and is heavily dependent on an irrigation network that was originally established during the British colonial period. According to Chaudary (2000), irrigation water with 200ppm salinity adds 0.28 tons of salt per hectare annually of which 75% goes into the ground. In Pakistan, about 6.30 million ha of land are salt affected and of this amount 0.94 m ha of saline patches are found in the Sindh province. This all happens due to poor canal irrigation system. At present in the lower part of Sindh, the water table is almost within 3 feet of the surface (Anon., 2005). The substantial rise in the water table because of a long history of over-irrigating the soils has caused salinity and water –logging to occur in large areas of Sindh.

Mangroves are woody plants that grow at the interface between land and sea in tropical and sub-tropical latitudes where they exist in a wide range of conditions e.g., high salinity, extreme tides, strong wind, high temperature, muddy soil and in anaerobic condition. However, they are also abundant in river Indus delta where there are low saline conditions and thus even manage to extend upstream beyond the tidal influence. The mangrove forest is dominated by evergreen sclerophyllous broad-leaved trees with pneumatophores and viviparous seedlings (Anon., 1973). Mangroves have a remarkable capability to cope with saline environments. There may be no other group of plants with such highly developed morphological and physiological adaptations to extreme conditions (Kathiresan *et al*., 2001).

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Mangroves are commonly associated with tropical and subtropical coastlines and only a few species extend their range into the cooler warm temperate climates that are typical of parts of New Zealand, Australia, Japan, South America and South Africa (Chapman 1977, McNae 1966). A latitudinal pattern of species richness is evident, with diversity and extent both greatest at the equator and diminishing pole- wards to both the North and South (Ellison, 2002).

The mangroves take crucial importance ecologically as well as economically. Its timber is used as fuel, however is not advisable. The leaves of *Avicenna marina* are eaten by all kinds of creatures; cattle use them as a fodder, while the insects nibble on them. Fallen leaves are an important source of nutrients; they are rapidly broken up by small creatures, and further broken down by micro-organisms into useful minerals. There are even tiny moth larvae that feed on pneumatophores. Mangrove trees also slowly regenerate the soil by penetrating and aerating it. Similar situation (water logged, anaerobic and saline) also exists in degraded agriculture lands which is favorable for Mangrove (*Avicennia marina*), therefore a trial was conducted in degraded portion of agricultural land to investigate whether this species could be used to reclaim or manage waterlogged and saline agricultural areas by using mangrove's adaptability.

Materials and Methods

Two different experimental sites were selected to observe the growth potential of *Avicennia marina*. The experiment was started in the mid of July 2007.The seeds of *A. marina* were collected from Sandpits area.

Soil and water samples were collected from both natural and experimental sites and analysis was performed. The first set of the experiment was carried out in one hundred pots sized (20x15cm). Each contained half kg mud, which was collected from Sandspit. Hundred healthy propagules were selected for trial to investigate the establishment, survival and growth of seedlings of *Avicennia marina*. After taking their length and breadth, the seeds were sown into the polythene bags. However, care have taken to see that the seeds are not buried too deeply. It has been noted that propagules of *Avicennia marina* will not germinate unless they have enough moisture to shed (testa) the seed coat (Steinke,1975). For this reason the testa is often allowed to drop off, or is removed, prior to plant. (Colin Field, 1996). Half bags were kept in the sunlight at Sandspit which got sea-water while half were taken at University ,kept in green house and watered by fresh water once a day. The percentage of germination, length of radical and plumule elongation were measured.

Another set of experiment was conducted in open land areas. The particular saline land was chosen at two different sites. The first site was selected in Sandspit area in natural environment while the second site was selected in Botany Department of Federal Urdu University where land was divided into three columns and four rows. In each column, the distance between two seedlings was 3.5 feet while in rows it was taken as 4.5 feet. Same technique was applied at Sandspit areas. After 10 days seedlings raised in polythene bags and were transplanted in small holes 4″ depth at the planting sites. Seedling's height and number of leaves were recorded every month. For determination leaf area of *A. marina* fully expanded leaves were collected from several plants following the method Samarakoon *et al*., (1990) and was determined by Ahmed (1973). The student t-test was also applied to compare the data of these two different locations.

Result and Discussion

Germination started within four days and 100% completed within 15 days at both sites. Maricar *et al*., (2008) recorded higher mortality and stunted growth in non-mangrove areas; however, this was not the case with *Avicennia marina* in our studies.

Table 1 presents the soil and water analysis of both experimental sites. pH values of water sample ranged from 8.05±0.35 and 8.63±0 while the pH of soil ranged from 8.4±0.1 to 8.6±0.01 are within maximum permissible limit prescribed by WHO which favor for growth of algae (Smith & Smith, 1998). Conductivity, TDS and salinity values of water were significantly higher in FUU. The soil of Sandspit area showed significantly difference in salinity, TDS and conductivity compared to FUU. It is anticipated that Sandspit area is indicating extreme situation. The experimental site has slightly better soil aeration for the growth of plants.

Table 2 represents the morphological characteristics of the seeds. The seeds of *A. marina* are semi-viviparous. Fully mature *Avicennia* propagules showed the following characteristics: the colures of the seed coat changes from greenish to yellowish; cracks appeared on the seed coat, the mean length of seeds was 2.74±0.074 cm to 2.77±0.071 cm while there breadth was 4.75±0.07 and the calculated area was 13.03±0.46 to 13.16±0.41cm.The rate of germination in collected seeds and in F1 generation seeds was 100% although they were sown is different environments. The non-significant difference in their mean values showed that they enjoyed normal condition as well, indicating higher potential for non-mangrove sites. The length of radical and plumule elongation were measured. The radical length in Sandspit area was 3.27±0.47 whereas the seedling grown in site B showed mean radical length 2.75±0.31.The plumule elongation in site A was 2.6±0.39 and at site B it was 1.9±0.47. Both the parameters were showed slightly high measurement in site A (natural environment) as compared to site B which may be due to high availability of nutrients at their initial growth stages. However, no significant difference was recorded between these values.

Table 3 describes the mean height of seedling, number of leaves, leaf length, leaf breadth, leaf area, and number of pneumatophores per plant. The height was recorded upto fourteen months. The mean height of seedlings at site A was 45.19±2.86cm whereas the height of seedlings at site B was 51.64±4.85cm (Fig. 3).The result showed that these plants showed best results in degraded agricultural soils. The mean number of leaves, length /breadth and area of leaf of Site A is slightly higher compared to site B. The mean, area of leaves at location A was 28.86±1.21 while at location B 21.92±0.66; it may be due to exposure to ultra violet radiation, which are intense at coastal region as compared to the hinterland. However, both sites showed no significant difference in these parameters. Two pneumatophores developed after two months of plantation, but soon vanished and during two years trial none appeared at site B while 93 pneumatophores developed at site A. Flowering was started in early May in Sandspit (site A) while in FUU (site B) flowering initiated in late May. At experimental site, plant produced normal viable seeds hence; it was pragmatic that even in saline soil the seedlings of *Avicennia marina* showed the finest growth with aerobic respiration so they didn't need to generate pneumatophores. However, stilt root like structure (similar to prop roots of *Rhizophora mucronata)* generated from the lower stem just to support one plant (Fig. 2).

Table 1. Physical parameters of water and soil from both the sites.

Location	pH	Conductivity mS/cm	TDS g/L	DO mg/L	Salinity %
			Water		
SAND (A)	8.05 ± 0.35	60.55 ± 3.05	38.73 ± 0.53	4.09 ± 0.09	4.025 ± 0.055
FUU (B)	8.63 ± 0.13	66.0 ± 1.0	31.1.5 ± 0.6	4.73 ± 0.03	0.4 ± 0.1
	ns	*s	*s	ns	*s
			Soil		
SAND (A)	8.4 ± 0.1	11.5 ± 0.2	6.2 ± 0.1	1.4 ± 0.1	6.4 ± 0.1
FUU (B)	8.6 ± 0.01	6.3 ± 0.01	3.2 ± 0.01	1.4 ± 0.01	3.3 ± 0.1
	ns	*s	*s	ns	*s

SAND= Sandspit, FUU= Federal Urdu University, Ns= Non-significant, S= Significant

Fig. 1. Seedling after nine months.

Fig. 2. Appearence of stilt roots.

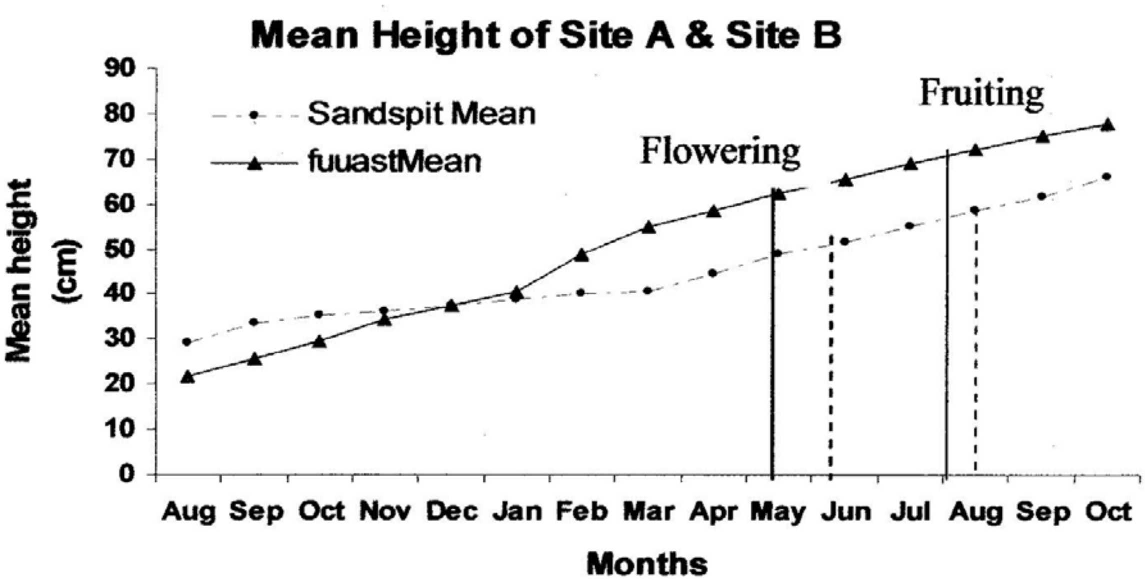

Fig. 3 Monthly variation in mean height (15months) of plants of two locations with flowering and fruiting. Vertical black lines showing the flowering on both sides while red lines indicate the fruiting on both locations.

Table 2. Length/breath and area of seed, germination of seed, length of radical and plumule of *Aviceenia marina* from both locations.

Locations	Length of seed (mm)	Breadth of seeds (mm)	Area of seed (mm)	Germination (%)	Radical length (cm)	Plumule length (cm)
SAND (A)	2.77 ± 0.071	4.75 ± 0.071	13.16 ± 0.41	100	3.27 ± 0.47	2.6 ± 0.39
FUU (B)	2.74 ± 0.074	4.75 ± 0.07	13.03 ± 0.46	100	2.75 ± 0.31	1.9 ± 0.47
	ns	ns	ns	ns	ns	ns

SAND= Sandspit, FUU= Federal Urdu University, Ns= Non-significant

Table 3. Mean height, number of leaves, leaf area, days of initial flowering, days of initial fruiting and number of pneumatophores of *Avicenia marina*.

Locations	Mean height of plants cm	Mean number of leaves	Mean length of leaves cm	Mean breadth of leaves cm	Mean area of leaves cm	Days of initial flowering	Days of initial fruiting	No. of Pneumatophores
SAND (A)	45.19 ± 2.86	55.00 ± 7.34	10.98 ± 0.26	3.9 ± 0.1	28.86 ± 1.21	164.7 ± 28.1	207.8 ± 31	93
FUU (B)	51.64 ± 4.85	54.63 ± 7.32	9.98 ± 0.16	3.28 ± 0.07	21.92 ± 0.66	166.1 ± 28.8	209.2 ± 31.7	0
	ns	ns	ns	ns	ns	ns	ns	s

SAND= Sandspit, FUU= Federal Urdu University, Ns= Non-significant

Conclusion

The results showed no significant difference in germination, growth, production and survival of *Avicennia marina* between normal and water logged and saline agricultural land with significantly higher conductivity, TDS and salinity. Therefore, it may be suggested that this species is highly potential to reclaim waterlogged and saline agricultural areas of Sind. It is anticipated that beside reducing water logging, improving soil condition and microclimatic situation, it would increase the productive capacity of the land. A large-scale plantation of this species in these areas would also increase fuel wood and charcoal production, resulting economic benefit to the local people.

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