

# Mangrove Seedling Development Under Different Salinity

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## Abstract

Two mangrove species *Avicennia marina* (Forsk.) Vierh and *Rhizophora mucronata* were selected to study the development of the seedlings under different salinity and growing media. The seeds were grown on soilless (water) and soil (sand) medium, with different water treatment, T1, T2, T3 and T4 (0ppt, 15ppt, 25ppt, 38-40ppt). Roots initiation, length, seedling height and survival were observed. The study shows that there's a statistically significance (*p*-Value of 0.039497) on the sapling development of *R. mucronata* and *A. marina* grown on salinity of 15ppt under soilless media, and there's no significant difference in root development between 15ppt, 25ppt and 40ppt. As comparison between *A. marina* seeds grown on soilless and sandy soil media (treated with water from T1, T2, T3 and T4) the height of the seedling grown on sandy soil treated with T1 tank (freshwater) has a statistical significance (*p*-Value of 0.0002071) difference compared to seedlings treated with T2, T3 and T4 (15, 25 and 40ppt). In conclusion, the two mangrove species show significant seedling development on a soilless media under water treatment with salinity of 15ppt.

Keyword: mangrove, *R. mucronata*, *A. marina*, salinity, seedlings, soilless system

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## 1. Introduction

The United Arab Emirates (UAE), mangrove ecosystem have only one real mangrove species, *Avicennia marina* which can be found abundant on UAE's coastal areas. *A. marina* is widely distributed, ancient old standings can be found on Khor Al Beidah in Umm Al Quwain and Khor Kalba in Sharjah (Scott, D.A., IUCN 1995). *R. mucronata* was reported as another mangrove species in the UAE, but it cannot be found on the country's mangrove areas and only re-introduced between 1983 to 1986 in Mubarras Island of Abu Dhabi and in Ras Ghanada Island, North East of Abu Dhabi on 2008 (Yousif, O.M. and Sen, Sumitro, 2020).

Gray mangrove and red mangrove are high salinity tolerant species, with *R. mucronata* as the most popular species used for mangrove restoration but in the UAE, *A. marina* is the sole species used for the country's successful mangrove planting projects. For decades the country's continuous effort on coastal rehabilitation through mangrove planting, specifically the Sabkha areas, the mangrove extent increased significantly from 3500 hectares on 1978 to 13615 hectares on 2013 (Moore, GE, et al, 2013).

Aquaculture in mangroves is a practice for decades in several parts of the world, mangrove serves as natural shelter and protection for aquaculture ponds and as breeding and nursery grounds for many marine animals. Also aquaculture effluents, can be a potential source of nutrients for mangrove trees, healthy grey mangrove standings, planted along fish farm drainage canal (Shigeyasu Tamaei, et al, 2002). Soilless system or hydroponics is growing plants using liquid as the media for cultivation, and aquaponics is a combination of hydroponics and aquaculture (Thakulla, Darti, 2021). Aquaponics has two separate systems; the first part is “aqua” which refers to aquaculture or rearing fish, and the second part is “ponics” which refers to the growing technique of plants (Underwood, J.). The nutrient-rich water feeds the soilless grown plants, were the primary source of nutrients is ammonia which is converted into nitrates thru nitrification process by nitrifying bacteria.

On this paper, seedling development, root initiation and survival were observed to study the effect of different salinity (0ppt-freshwater, 15ppt, 25ppt and 38-40ppt-seawater) on mangrove saplings cultivated on two different media (soilless and sandy soil). Data for roots length, seedling height, survival were gathered. Moreover, water parameters (Table 1) on each treatment (T1, T2, T3, T4), salinity, temperature, dissolved oxygen, pH, TDS and nutrients (Ammonia, Nitrate, Nitrite and Phosphate) and soil samples were submitted in MOCCA Central Laboratory for soil analysis (Table 2).

## **2. Methodology**

### **2.1.a. Plant Materials and Cultivation**

*R. mucronata* seeds from Indonesia were used for this study. The seeds were washed with freshwater, the saplings were washed several times with freshwater and soaked on freshwater for 24 hours. After 24 hours, the saplings were directly cultivated on each tank.

The *A. marina* seeds were collected from the mangrove forest in Umm Al Quwain, UAE on the months of August to September. The seeds were washed and rinsed with freshwater, and directly cultivated on a floating seedling tray, 49 grey mangrove seeds per tray. The seedling tray were placed on the water surface of each tank, Tank 1 (0 ppt), water from Tank 2 (15-17 ppt), water from Tank 3 (25-27 ppt) and water from Tank 4 (38-40 ppt) with 15 seeds each water treatment. After 24 hours the pericarp peeled off and removed from the tray to avoid fouling, seeds then placed back to the seedling tray. All saplings were grown inside the Laboratory with the average room temperature of 26.59°C and relative humidity of 43.71%.

### **2.1.b. Growing Media Preparation**

A polycarbonate tank, with 30 liters capacity was used, each tank were properly connected with aerator for oxygen supply. Freshwater were initially added on the tank for water conditioning, after 7 days, 20 pieces of Tilapia (mixed species) with weight ranging from 2.0grams to 30grams and length varying from 2cm to 15cm

were added onto the 4 tanks. After transferring the fish, the salinity on Tank 2, 3 and 4 were adjusted every 2 days to reached the salinity 15ppt (T2), 25ppt (T3) and 40 ppt (T4). To avoid ammonia building-up, daily water freshening at 40% was done. The Tilapia were fed 3 times daily with 80% commercial fish feeds and 20% ground dried seaweed (*Ulva spp*). Using a multi-parameter water meter, the water physical parameters were monitored 3 times per week, Ammonia, Nitrate, Nitrite and Phosphate were analyzed every 14 days throughout the duration of the study. The average value (Table 1) of Temperature, pH, dissolved Oxygen, Ammonia, Nitrate, Nitrite and Phosphate have no significant difference except for the salinity.

| <b>Table 1. Water Treatment/Soilless media</b> |           |                        |           |           |
|------------------------------------------------|-----------|------------------------|-----------|-----------|
| <b>Average Value</b>                           |           | <b>Water Treatment</b> |           |           |
| <b>Parameters</b>                              | <b>T1</b> | <b>T2</b>              | <b>T3</b> | <b>T4</b> |
| Temperature °C                                 | 27.80     | 28.00                  | 27.90     | 27.80     |
| Salinity ppt                                   | 0.00      | 14.84                  | 25.41     | 39.96     |
| pH                                             | 8.20      | 8.30                   | 8.20      | 8.20      |
| Dissolved Oxygen ppt                           | 7.44      | 7.35                   | 7.37      | 7.36      |
| Ammonia ppt                                    | 2.00      | 2.00                   | 2.00      | 4.00      |
| Nitrate ppt                                    | 2.25      | 2.25                   | 2.25      | 2.25      |
| Nitrite ppt                                    | 0.05      | 0.01                   | 0.01      | 0.01      |
| Phosphate ppt                                  | 0.03      | 0.1                    | 0.03      | 0.1       |

Sandy soil is commonly used in the mangrove nursery established in the Marine Environment Research Department (MERD) in Umm Al Quwain for growing mangrove (*A. marina*) seedlings. Before planting, 1 kilogram of the soil were set aside and sent to the MOCCA Central Laboratory for complete soil analysis (Table 2) the sandy soil media is high CaCO<sub>3</sub> and available potassium. A plastic seedling pot was used and filled with sandy soil for the soil media application.

| <b>Table 2. Soil media analysis results</b> |                   |
|---------------------------------------------|-------------------|
| <b>Laboratory Tests</b>                     | <b>Sandy Soil</b> |
| pH                                          | 8.10              |
| Electro Conductivity/EC mmhos/cm            | 10.79             |
| Calcium Carbonate (CaCO <sub>3</sub> )%     | 63.29             |
| Organic Matter %                            | 2.41              |
| Manganese (Mn) ppm                          | 8.40              |
| Iron (Fe) ppm                               | 5.80              |
| Copper (Fe) ppm                             | 2.40              |
| Zinc (Zn) ppm                               | 10.80             |
| Available Potassium (K) ppm                 | 5195.00           |
| Available Phosphorus ppm                    | 18.50             |

### 2.1.c Sapling growth measurements

The roots development for *R. mucronata* were measured in terms of length (in cm) every seven days after first root initiation was observed and for *A. marina*, daily observation was done after development of root hairs and after the appearance of the first root, length was measured every 7 days in centimeters (cm). For germination percentage, the seedling establishment was used as an indicator, recording the appearance of the first leaf (de Silva, W. and Amarasinghe, M. 2021) of the two species. Shoots height (in cm) were measured from the epigeal cotyledon to the base of the apical leaf (Pinzon *et al.* 2003).

## 3. Results and Discussion

### 3.1 Results

The seed germination percentage of *A. marina* saplings grown under 15-17ppt salinity in soilless was 60% while the saplings grown on soil (sand) media was 40%, and the saplings grown with 0ppt (freshwater), on soilless media the germination percentage was 21% whereas in soil media the percentage was 80%. While the sapling grown under 25-27ppt and 38-40ppt on the soil media was 0% after the 40 days trial period, in contrast to the sapling grown thru soilless media the percentage was 48% for 25-27ppt and 21% under 38-30ppt. Although the *R. mucronata* was able to developed roots, initiation of leaf development was observed in 15-17ppt after 60 days. Roots development, root initiation started after 7 days of cultivation with *R. mucronata* on all water treatment (0ppt, 15-17ppt, 25-27ppt, 38-40ppt) with the soilless media. The saplings on 0ppt shows good roots initiation with initial roots length of 0.3cm, but after 16 days, the root length in 0ppt (T1) started to developed slowly while the length of the roots on 15ppt, 25ppt and 38-40ppt (T2, T3 and T4) increased progressively. After 44 days of cultivation, the root length of the saplings on the T2 significantly increased as compared to length of the roots of the sapling cultivated on T1, T3, and T4 (Figure1). First leaves initiation were observed on the saplings cultivated in T2 water treatment (15ppt) after 60 days of cultivation.

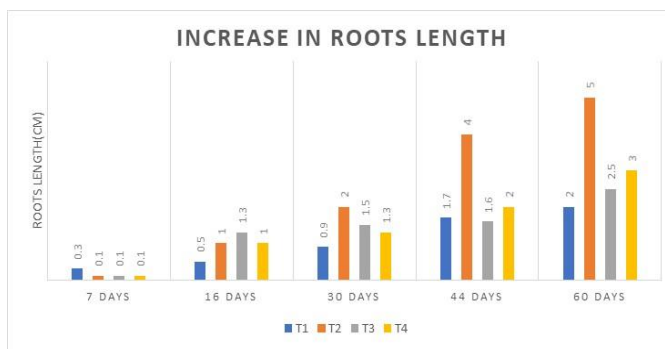
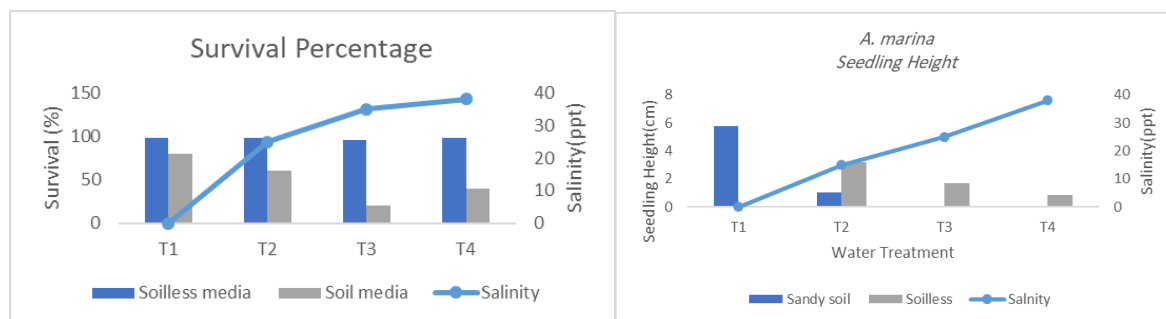


Fig. 1. *R. mucronata* saplings increase in root length during the 60 days observation

*A. marina* saplings cultivated on soilless and sandy soil media under different water treatment were observed for a period of 40 days. The effect of the water treatment cultivated on two different growing medium shows significant difference. Survival percentage of saplings grown on the two media has significant difference, the effect of salinity on the saplings shows that the saplings on soilless media with water treatment under 0ppt, 15ppt and 38-40ppt has good survival percentage 98% and 96% survival percentage of seedlings under 25ppt. The saplings on sandy soil media with 0ppt water treatment has higher percentage of survival at 80%, while saplings treated with 25ppt water has 20% survival (Figure 2.a).

The seedling height, during the trial, on the soil media under T1 water treatment has an average height of compared to 5.75cm soilless media, T2 water treatment (15ppt) has a good effect on the seedling development of *A. marina* (Figure 2.b). In 15ppt salinity-T2 water treatment around 70% of the seeds already developed into saplings, with 57% and 43% in T3 and T4 and 0% on T1. The average number of leaves on 15ppt, 25 ppt, and 38-40 ppt are all ranging from 2 to 4 leaves.



**Fig. 2. (a) *A. marina* survival percentage under different water treatment; (b) seedling height of *A. marina***

### 3.2 Discussion

Variation on water salinity shows the tolerance of the two mangrove species, *R. mucronata* and *A. marina*. The development of roots of both mangrove species grown in soilless media under 15ppt indicates that it is the preferable salinity level for establishing root system, and the roots length development is also better on water treatment with higher salinity (25ppt and 38-40ppt-natural seawater of the UAE). The low levels of the Ammonia, Nitrate and Phosphates indicates that the healthy root system of the saplings grown on 15ppt soilless water treatment has good nutrients absorption, and saplings on this treatment were the first to initiate leaves.

#### 4. Conclusion

*A. marina* and *R mucronata*, both manifested to tolerate higher salinity (40ppt). The two mangrove species developed best on 15 ppt in terms of roots development and seedling height. The results also shows that cultivating mangrove seedlings at different salinity(15ppt to 40ppt) with soilless media can be an alternative option on growing mangrove seedlings in the UAE.

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#### VI. References

- Tamaei, S., Jamali, E.A.,Anwahi, A.A., Al-Janahi, A.A., 2002. Exeprimental Cultivation of Gray Mangrove (*Avicennia marina*) combined with aquaculture in UAE, Emirates Journal of Agricultural Research, Dubai, 2002, 4, 39-57
- Rabanal, H.R., Beuschel, 1978. The Mangroves and related coastal fishery resources in the United Arab Emirates. FAO, Rome.
- FAO 2007. The world's mangroves, 1980-2005: A thematic study in the framework of the Global Forest Resources Assessment 2005 Food and Agriculture Organization of the United Nations, Rome.
- Moore, G.E., Grizzle, R.E.and K.M. Ward. 2013. Mangrove resources of the United Arab Emirates: Mapping and site survey 2011-2013. Final Report to the United Arab Emirates Ministry of Environment and Water.
- Guillermo, F and Killilea, M.E.,2024, J.A.Burt (ed.), Mangrove Ecosystem of the United Arab Emirates, A natural History of the Emirates, 7:217-240, [https://doi.org/10.1007/978-3-031-37397-8\\_7](https://doi.org/10.1007/978-3-031-37397-8_7)
- M. Basyuni et al, 2020. Root Development in Mangrove plant *Rhizophora mucronata* Under Different Shade Intensities, IOP Conf. Ser.: Earth Environ. Sci. 452 012090
- De Silva, W. and Amarasinghe, M. 2021.Response of Mangrove Plant Specis to Saline gradient: Implications for Ecological Restorartion, Acta Botanica Brasilica- 35(1): 151-160, doi: 10.1590/0102-33062020abb0170
- Pinzon, Z.S., Ewel, K.C.;Putz, F.E., 2003.Gap Formation and Forest Regeneration in a Micronesian Mangrove Forest, Journal of Tropical Ecology, 19:143-153,doi: 10.1017/S026646740300316X
- M. Basyuni et al, 2018. Growth and Root Development of Four Mangrove Seedlings Under Varying Salinity, IOP Conf. Ser.: Earth Environ. Sci. 130 012027
- Kathiresan, K., Rajendran, N.,2002. Growth of a mangrove (*Rhizophora apiculata*) seedlings as influenced by GA3, light and salinity, International Journal of Tropical Biology and Conservation, Rev. Biol. Trop. 50(2): 525-530, 2002
- Yousiuf, O.M., Sen, S., 2020. Reintroduction of red mangrove *Rhizophora mucronata* in Abu Dhabi Emirate, United Arab Emirates, World Journal of Advanced Research and Reviews, 2020, 07(02), 210–217
- Samara, F., Solovieva, N., Ghalayini, T.,Naerallah, Z.A.,Sabunova, M.,2020. Assessment of the Environmental Status of the Mangrove Ecosystem in the United Arab Emirates, Water 2020, 12, 1623; doi:10.3390/w12061623
- Underwood, Jimi, Aquaponics, Oklahoma Cooperative Extension Fact Sheets, HLA-6721
- Thakulla, Dharti, 2002.Soilless Growing Medium, Oklahoma Cooperative Extension Fact Sheets, HLA-6728
- Chen, Y. and Ye, Y., 2012. Effects of Salinity and Nutrient Addition on Mangrove *Exoecaria agallocha*, PLOS ONE 9(4): E93337. Doi:10.1371/journal.pone.0093337