Sea level rise impact on mangrove growth and development in Coral Triangle Ecoregion Southeast, Indonesia

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Abstract. The mangroves are among the most at-risk coastal ecosystems, which are especially vulnerable to sea-level rise. This study aimed to know the growth capacity and biochemical defense of mangrove seedlings of Rhizophora mucronata under different sea water logging at experimental condition in Kendari bay, Southeast Sulawesi, Indonesia. Results showed that maximum leaf area, intrinsic rate increase of leaf area and relative growth rate (RGR) of height of the R. mucronata seedlings were significantly higher at treatment of 45 cm from the ground than other treatments, whereas RGR of diameter was the higher at treatment of 30 cm from the ground. Meanwhile, half expansion period leaf area was almost similar for all treatment. However, the carbon and nitrogen ratio in leaves of R. mucronata seedlings was significantly higher at seawater logging of 0 cm from the ground. The flavonoid and vitamin C concentrations in R. mucronata seedlings were higher at higher level inundation indicating protective role of these compounds under seawater logging stress.

1. INTRODUCTION

The mangrove ecosystem is among the most at-risk ecosystems from sea-level rise. Therefore, understanding which mangrove stands are able to survive under sea-level rise, managers can identify and protect refuges that self-seed and act as sources for seeding of future mangrove communities.

However, recent condition of mangrove ecosystems throughout the world are suffered due to global warming and anthropogenic pressures, and are influence the resistance of mangrove ecosystems,
which play very important roles as one of primary producers to support the productivity of coastal zone and human life at the coral triangle ecoregion. The mangroves in Southeast Sulawesi consists high diversity including Rhizophora apiculata, R. mucronata, and Ceriops tagal [1]. Other studies in this area highlighted the potential of mangroves bio-prospecting [2, 3], allometric model and biomass [4, 5] and mangroves bio-filtering capacity [6].

Elucidation on resistance of mangrove forest under global climate change is needed for projecting how does this ecosystem will be affected by sea level rise pressure. This study aimed to know the growth capacity and biochemical defense of mangrove seedlings under different sea water logging at experimental condition in Kendari bay, Southeast Sulawesi, Indonesia.

2. LITERATURE REVIEW

The ability of mangroves to adapt growth with sea-level rise depends on accretion rate relative to rate of sea-level change [7]. [8] found that seedlings in the tanks simulating sea-level rise initially grew faster than plants in the other treatments, but grew slowly at sapling stage. [9] found that the mangroves along macro-tidal (>4 m) coastlines, along wet tropical coasts and/or in areas adjacent to significant river input, are the least vulnerable to the impact of sea-level rise.

Mangroves are biochemically unique, producing a wide array of novel natural products to adapt growth and sustain with environmental stress. For example Excoecaria agallocha exudes acrid latex that is injurious to the human eye, hence its designation as “the blinding tree”. The latex is toxic to a variety of marine organisms [10, 11]. Mangroves are rich in polyphenols and tannins [12, 13].

3. RESEARCH METHODS

3.1. Site description

This study was carried out at the mangrove forest of Kendari Bay located at the Kendari city in Southeast Sulawesi province. The mangrove condition provides an excellent site for establishment of sea level rise effect on mangroves because the growth and development of mangroves showed good condition, though extensive mangrove land conversion are happen.

3.2. Experiment the effect of sea level rise on mangroves

We grew the five mangrove seedling in four different height of pipes, i.e. (1) 0 cm from the ground, (2) 15 cm above ground, (3) 30 cm above the ground, and (4) 45 cm above the ground. During high tide the water levels were 30 cm, 45 cm, 60 cm and 90 cm, respectively. The experiment are monitored every two days. The growth parameters such as stem diameter, and the height of seedlings were measured three times a week. Biochemical and physiological data collection determined at the end experiment and harvesting of plant material. The proline and alcoholic dehydrogenase were analyzed. In addition, biocehmical analyses were done for antocyanin, flavonoid, alkaloid, tannin and vitamin C. Meanwhile, carbon organic and nitrogen content were determined from seedlings in whole treatment.

4. RESULTS AND DISCUSSION

4.1. Mangrove leaf area growth

Leaf area growth of R. mucronata seedlings presented in Figure 1. As shown in Figure 1A, the maximum leaf area was significantly higher at seawater logging of 45 cm (24.62 cm²) from the ground than treatment of 30 cm (12.10 cm²), 15 cm (17.92 cm²), and 0 cm (14.21 cm²) from the ground. Moreover, intrinsic rate increase of leaf area (Figure 1B) was not significantly different among treatments of 45 cm, 30 cm, 15 cm and 0 cm from the ground was estimated as 0.13 d⁻¹, 0.25 d⁻¹, 0.14d⁻¹and 0.18d⁻¹, respectively. Similar trend showed to half expansion period (Figure 2C) of leaf area of R. mucronata seedlings. Therefore, sea level rise seemed to reduce the area of leaf of the mangrove of R. mucronata seedlings.
Figure 1. Trends in leaf area growth parameters of *R. mucronata* seedlings based on different seawater logging level. (A) maximum leaf area (*U*); (B) intrinsic rate increase (*λ*); and (C) half expansion period (*t*). Similar letter indicates no significantly different.

4.2. Mangrove relative growth rate
Relative growth rate (RGR) of height and stem diameter of mangroves seedlings is represented by Table 1 below. It shows that the RGRs of height and stem of *R.* lower were the lower at treatment of 0 cm of seawater logging or deeper seawater, but faster at lower level of seawater logging, indicating sea level rise affect the growth of mangrove seedlings. However, mangroves can activate diverse components of their antioxidative system to restrict effect of seawater stresses of salinity and improving the good mangroves growth under tidal influenced varied saline condition. Sea level rise might reduce growth rate of mangrove seedlings at the present study that flooding and salinity might stressed the growth of *R. mucronata* seedlings. As found by [7] that sea level rise might reduce survival and growth performance of mangroves seedlings, expressed as biomass decrement due to variation in flooding and salinity. They also found that relative growth rate of *Bruguiera gymnorrhiza* decreased significantly with waterlogged time, but it was no clear effect of waterlogged to the growth of *Kandelia candel* plants.

| Mangroves  | Seedlings position from the ground | RGR of height (cm)  | RGR Diameter (cm) |
|------------|------------------------------------|---------------------|-------------------|
| *R. mucronata* | 45 cm                             | 0.13±0.007a         | 0.034±0.011a      |
|            | 30 cm                             | 0.09±0.009b         | 0.037±0.014a      |
|            | 15 cm                             | 0.08±0.010bc        | 0.036±0.005a      |
|            | 0 cm                              | 0.06±0.007bcd       | 0.014±0.005b      |
4.3. Biochemical adaptation

Table 2 depicts chemical compounds concentration as biochemical adaptation of *R. mucronata* seedlings under different seawater logging level. The flavonoid and vitamin C concentrations were higher at seawater treatment of 0 cm from the ground or higher level inundation indication protective role of these compounds under seawater logging stress. However, concentration of anthocyanin, proline and alcohol dehydrogenase as well as C/N ratio did not show clear trends indicating unclear their function under seawater logging treatment. [7] found that the chlorophyll contents of *K. candel* and *B. gymnorrhiza* increased in response to waterlogging. This is the way for these mangroves seedlings to survive in the environmental stress of sea waterlogging. However, our study shown that the seedlings of *R. mucronata* produce various chemical compounds to adapt growth in the stressing of seawater logging.

Table 2. Chemical compounds production as biochemical adaptation of *Rhizophora mucronata* seedlings under different seawater logging. Similar letter indicates no significantly different.

| Mangroves        | Compounds       | 45 cm         | 30 cm         | 15 cm         | 0 cm         |
|------------------|-----------------|---------------|---------------|---------------|--------------|
| *Rhizophora mucronata* | Flavonoid       | 0.20 ± 0.03 a | 0.33 ± 0.03 b | 0.30 ± 0.07 a | 0.53 ± 0.11 b |
|                   | Vitamin C       | 0.10 ± 0.01 a | 0.14 ± 0.01 b | 0.14 ± 0.00 c | 0.16 ± 0.00 b |
|                   | Prolin          | 18.34 ± 0.39 a| 17.95 ± 0.24 b| 16.68 ± 0.15 a| 6.48 ± 0.18 b |
|                   | Alcoholde-      |               |               |               |              |
|                   | hydrogenase     | 0.61 ± 0.05 a | 0.74 ± 0.09 b | 0.99 ± 0.07 b | 0.74 ± 0.08 c |
|                   | Rasio C/N       | 28.28718805 a | 31.85215243 a | 31.06056115 a | 32.2812531 b  |

5. CONCLUSION

The growth of mangrove *Rhizophora mucronata* seedlings affected by sea level rise, although they are able to growth better due to production of various chemical compounds.

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