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The effect of environmental factors on the growth of mangrove seedlings in Kauswagan, Lanao del Norte, Mindanao, Philippines

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Abstract. The effect of environmental factors on the growth of mangrove seedlings was determined. Four seedling species such as *Sonneratia alba*, *Rhizophora mucronata*, *Rhizophora apiculata* and *Aegiceras corniculatum* found in Kauswagan, Lanao del Norte were used in this study. Percent seedling growth was found to be highest in *R. apiculata*. Kawit Occidental was the most suitable area for growth and development of seedling. The effect of environmental factors on seedling growth was found to be species specific.

Key Words: Species specific, mangrove rehabilitation, seedling growth, *Sonneratia alba*, *Rhizophora mucronata*, *Rhizophora apiculata*, *Aegiceras corniculatum*

Introduction. Mangroves are a group of trees and shrubs which include a palm that are capable of growing in marine, estuarine and, to a limited degree, fresh water habitat. They occupy the fringe of intertidal shallows between the land and the sea (Stewart & Fairfull 2008). Mangroves generally grow in loose, wet soils, saltwater and are periodically submerged by tidal flows along sheltered coastal, estuarine and riverine areas in tropical and subtropical latitudes (Kasawani et al 2007). Mangroves have low or no capacity for a vegetative propagation and so they depend on the dispersal of seedlings (Tomlinson 1986). The growth and development of mangroves especially seedlings and propagules are greatly influenced by natural factors including salinity, temperature, pH, dissolved oxygen, nutrients, rainfall and tidal limits (Mitsch & Gosselink 2007). Seedling is a key factor for mangrove distribution. The seedling establishment and growth would extend mangrove distribution and increase land establishment as well.

Considering the importance of seedling for mangrove expansion, it is therefore important to know what are the environmental factors that would affect them most. The aim of this study is to determine the effect of the environmental factors on the growth of mangrove seedlings of *Sonneratia alba*, *Rhizophora apiculata*, *Rhizophora mucronata* and *Aegiceras corniculatum* in Kauswagan, Lanao del Norte.

Material and Method. The study was conducted in Kauswagan, the second coastal municipality of the Province of Lanao del Norte (Figure 1). It lies on the mid-central portion of the Northwestern Mindanao coastline (8° 9' 35'' N, 124° 5' 51'' E). Six sampling stations (Poblacion, Bagumbayan, Tacub, Libertad, Tugar and Kawit Occidental) were selected for the whole area of Kauswagan. Based on ocular estimates from transect mapping, the mangrove area in Kauswagan was found to be 0.46 hectare (Olaguir 2014).

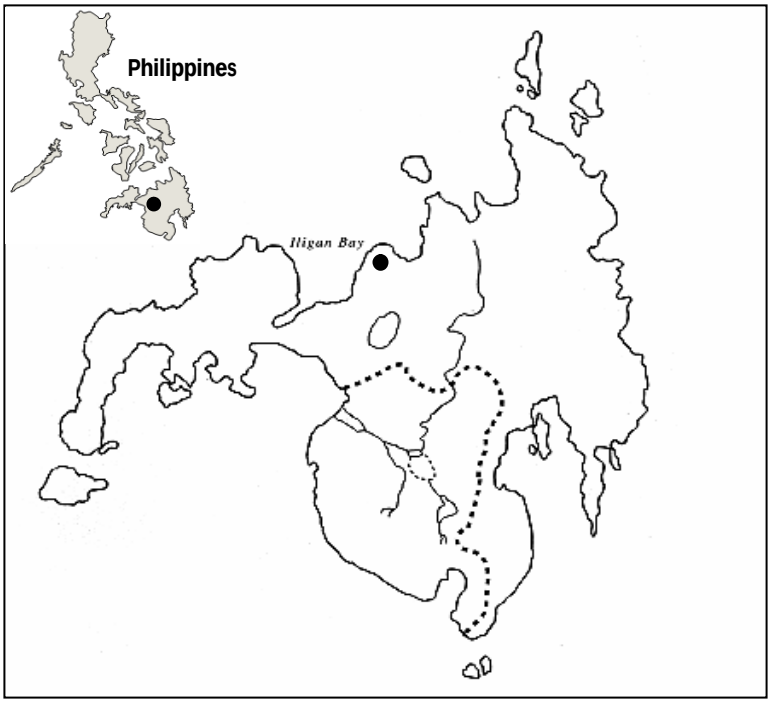

Figure 1. Map of Mindanao showing the sampling area of Kauswagan, Lanao del Norte in blackened dots.

One time assessment of environmental parameters and seedling growth was carried out from December 2013 to January 2014. Water temperature was measured *in situ* using an ordinary mercury thermometer, pH by pH meter, salinity by a handheld refractometer, dissolved oxygen by Winkler titration method (Grasshoff et al 1983), and nutrient (phosphate and nitrate) as described by Grasshoff et al (1983). Total organic matter was measured following the method of Moghaddasi et al (2009) and the value was expressed as percent total organic matter. Data on rainfall and tidal height were taken from the local weather station (Regional Forecasting Center and Surface Synoptic Station, Molugan PAGASA Complex, Molugan, El Salvador, Misamis Oriental).

Assessment of sapling and seedling was determined using the transect-quadrate method (English et al 1997). Sapling was classified according to height from 1 m to 4 m with diameter of less than 1 m, while seedling was classified according to height of less than 1 m (Ashton & Macintosh 2002). A 100 m transect line was pegged perpendicular to the shore with a 10 m interval between transects and within that transect line a 100 cm x 100 cm quadrate was set up. The sapling and seedling within the quadrate were counted per species and the values were expressed as density (number of individuals m^{-2}). Seedling growth was estimated using the ratio between sapling and seedling abundance (Hastuti et al 2012), and the value was expressed as percent growth following the formula:

$$\% \text{ Growth} = \text{sapling abundance} / \text{seedling abundance} \times 100$$

Univariate Analysis of Variance (level of significance, P of 0.05) in SPSS (version 20) was used to test the effect of species and sampling station on seedling growth. Simple linear regression analysis was used to determine the effect of environmental parameters on seedling growth.

Results and Discussion. The average values of the environmental parameters measured in six sampling stations are shown in Figure 2. Water temperature ranged between 29.41 – 31.00^0C while salinity ranged from 22.50 to 32.00 ‰. Some areas like Libertad, Poblacion, Bagumbayan and Kawit Occidental had lower salinity which is due to river inputs in the area. The measured water pH of the mangrove area in Kauswagan was acidic with the values ranging between 6.83-7.06. This result is considerable because of the abundant supply of sulfates and organic matter in the mangrove environment (Van der Kevie 1973).

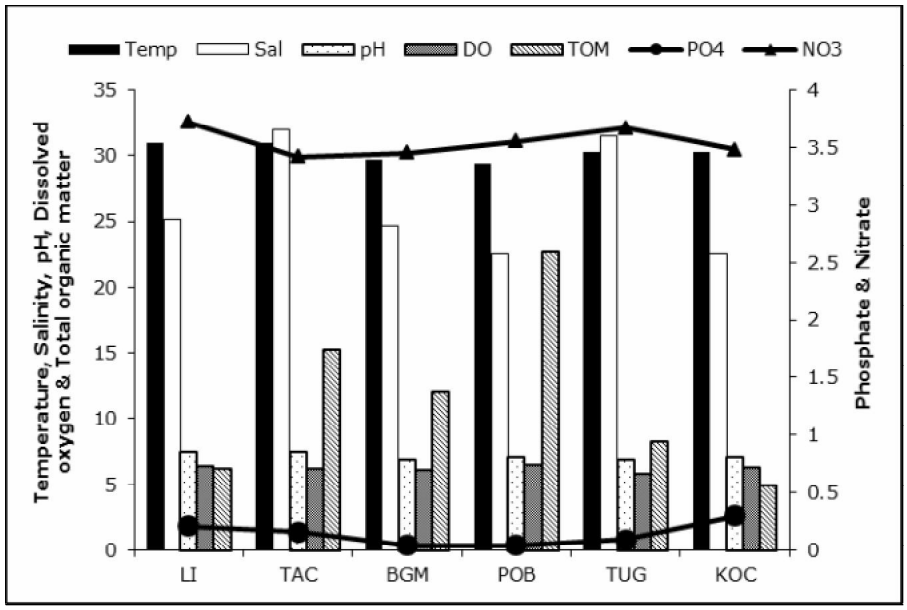

Figure 2. Environmental parameters (mean ± SD) measured in six sampling stations in Kauswagan, Lanao del Norte. LI - Libertad, TAC - Tacub, BGM - Bagumbayan, POB - Poblacion, TUG – Tugar, KOC - Kawit Occidental.

Dissolved oxygen ranged between 5.73-6.42 mg/L and the total organic matter 4.93-22.64%. The phosphate and nitrate were in the range of 0.01-0.48 mg/L and 3.0-4.50 mg/L, respectively. Kawit Occidental had the highest amount of phosphate followed by Libertad which attributed to the presence of rivers. The coast of Kauswagan has a semi-diurnal tidal type having two high and two low waters occurring in a day (Regional Forecasting Center and Surface Synoptic Station, Molugan PAGASA Complex, Figure 3).

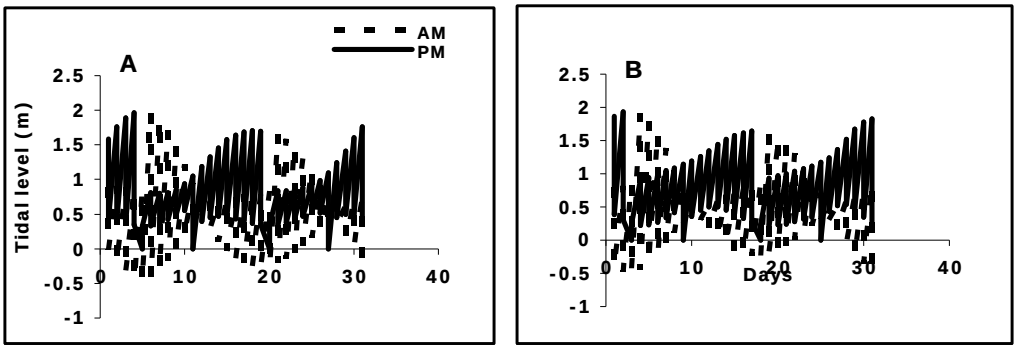

Figure 3. Predicted tidal oscillation curve in Kauswagan, Lanao del Norte during December 2013 (A) and January 2014 (B).

As a result, the mangroves in Kauswagan were regularly inundated or flooded due to the two high tides per day and this favors the growth of sapling and seedling. The maximum semi-diurnal tidal range in December was 1.73 m while it was 1.44 m in January. Average water depth was 0.97 ± 0.31 m in December and 0.98 ± 0.28 m in January, respectively. The amount of rainfall was higher in January (16.28 ± 3.28) than in December (0.45 ± 0.15). This result is considerable because January is a rainy month especially in the eastern and northern part of Mindanao. High rainfall could increase the water content of soils and delivers sediments and nutrients creating conditions that are favorable for mangrove physiological function (Smith & Duke 1987; Ball 1998).

Four species of mangrove seedlings were present in the area namely, *S. alba, R. apiculata, R. mucronata and A. corniculatum.* The seedling growth showed significant

differences among species and sampling stations (Table 1). *R. apiculata* had the highest seedling growth (120.34%; Table 2) and this can be due to the fact that most of the seedling and saplings of *R. apiculata* were found in shaded areas. This observation was further supported by the study of Kathiresan & Moorthy (1993), Kathiresan & Ramesh (1991) and Kathiresan & Rajendran (2002) on the seedling growth of *R. apiculata* under different light intensities. They found out that shade-grown seedling of *R. apiculata* showed better performance than under full sunlight. Mangrove seedlings are apparently adapted to shade understory environment while mature trees repond better in the sunlight canopy (Farnsworth & Ellison 1997). On the other hand, Kawit Occidental had the highest seedling growth (53.86%) showing that this area can be a good site for mangrove growth and reproduction.

Table 1

Statistical analysis (Univariate Analysis of Variance) on the effects of species and sampling area on seedling growth of mangroves in Kauswagan, Lanao del Norte

Dependent variable	*Independent variable*	*d.f.*	*F-statistics*	*p*	*Analysis*
Seedling growth	Species	5	6.090	0.040	Sig.
	Area	3	7.590	0.020	Sig.
	Species x Area	15	8.802	0.005	Sig.

Sig. – significant.

Table 2

The seedling growth (%) of mangroves with species and sampling station in Kauswagan, Lanao del Norte (mean ± SD)

Species	*Percent growth*	*Sampling station*	*Percent growth*
S. Alba	6.71 ± 2.31^{c}	Libertad	1.00 ± 0.04^{d}
R. apiculata	120.34 ± 98.45^{a}	Tacub	10.00 ± 1.43^{b}
R. mucronata	7.94 ± 2.21^{c}	Bagumbayan	8.03 ± 1.56^{c}
		Poblacion	1.00 ± 0.08^{d}
A. corniculatum	17.47 ± 10.45^{b}	Tugar	13.57 ± 3.45^{b}
		Kawit Occidental	53.86 ± 21.34^{a}

Letters represent differences in group means as determined by Tukey's test.

Changes in environmental factors are thought to affect growth and development in plants (Hastuti et al 2012). In this study, the effect of some environmental parameters on seedling growth was analyzed. The result of simple linear regression analysis showed that dissolved oxygen had positive effect on *S. alba* seedling growth (Adjusted R^2 = 92%). This means that an increase in dissolved oxygen would stimulate the growth of *S. alba* and vice versa. Dissolved oxygen is known to be one of the limiting factors in mangrove environment (Gerking 1978). Decrease in the amount of dissolved oxygen would lead to hypoxia and consequently affect the respiration rate of the root system hence decreases the root development. The total organic matter had a negative effect on the growth of *R. apiculata* seedlings (Adjusted R^2 = 87%) indicating that *R. apiculata* seedlings had limited capability on utilizing organic matter for growth. This result is similar with the study of Hastuti et al (2012) where organic matter showed a negative effect on the seedling growth of *Avicennia marina*. *R. mucronata* seedlings were positively affected by rain (Adjusted R^2 = 91%) which means that an increase in freshwater supply would stimulate the growth of *R. mucronata.* Freshwater supply has often been indicated by the ratio of rainfall to evapotranspiration. High input of freshwater to the mangrove community leaches out residual salts from the mangrove soil and thus encourages the growth of mangroves (Kathiresan 2008). Tide had a significant negative effect (Adjusted R^2 = 55%) on the seedling growth of *A. corniculatum* showing that the seedlings had a low capability to survive in changing tides. One of the most obvious effects of tide is the regular replenishment of the soil water across the whole area hence prevents waterlogging. Clarke (1995) observed that the propagules of *A. corniculatum* had low probability of dispersal because of tidal disturbance.

Conclusions. The present study reveals that the effect of the environmental factors on the growth of mangroves is species specific. Each of the four species of mangroves studied has a different environmental factor that affects its growth and development. This result should be taken into consideration in choosing the species of mangroves and the area which is suitable for mangrove rehabilitation.

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