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Photosynthetic and Respiration Responses of Dugong Grass *Thalassia hemprichii* (Ehrenb) Aschers. at Teluk Kemang Seagrass Bed, Malaysia

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Abstract: Photosynthetic and respiration responses were measured *in situ* at different depths and under a variety of light regime for seagrass *Thalassia hemprichii* from coastal area of Teluk Kemang, Port Dickson, Malaysia. The photosynthesis and respiration rate was measured from evolution of oxygen from the seagrass enclosed in glass cuvet. The photosynthetic rate at 0.5 m was higher (0.429 ± 0.086 mg O_2/hr/g fr wt.) than at 2.0 m depth (0.289 ± 0.034 mg O_2/hr/g fr wt.). Respiration rate was not significantly different at two depths. In laboratory study, the light saturation of *T. hemprichii* was reached at 400-800 μmol/m^2/sec, whereas, the compensation point was around 20 μmol/m^2/s. The photosynthesis was relatively constant at light intensity up to 1600 μmol/m^2/s. Comparing these results to *in situ* light measurement from the seagrass bed (1095.430±5.803 μmol/m^2/s at surface water and 115.00±1.512 μmol/m^2/s. at 2.0 m depth), this species depth distribution should not be light limited to a depth of about 2.0 m i.e. *T. hemprichii* could penetrate a depth of more than 2.0 m in this study area. However, the present field observation indicated that this species could only be found at intertidal area (1.5 - 2.0 m High Water Level) and assumed that other environmental factors i.e. current movement, water visibility and sediment status may affects the depth distribution of this seagrass in this costal water.

Key words: Seagrass, photosynthesis, respiration, *Thalassia hemprichii*, Malaysia

Introduction

Seagrasses are usually found in near shore coastal areas all over the world. The ecological importance of seagrass as primary producers, sediment stabilizers and as habitat and nursery areas for many marine animals is well recognized (Pollard, 1984; Fonseca and Fisher, 1986; Bell and Pollard, 1989). Besides current movement (Fonseca and Kenworthy, 1987), water turbidity (Cambridge and McComb, 1984), nutrient availability (Kenworth and Fonseca, 1992; Murray *et al*., 1992 and Perez *et al*., 1994) and water temperature (Walker and McComb, 1990; Prerez and Romero, 1992 and Bulthuis, 1987), light regime is an important factor that influences the photosynthesis, growth and depth distribution of seagrass (Dennison and Alberte, 1982; Dennison, 1987 and Duarte, 1991). However, availability of light in coastal areas is a function of light attenuation, which is affected by environmental factors such as sedimentation, current direction and shading by epiphytic or unattached algae (Karenne, 1994; Silberstein *et al*., 1986 and Shepherd *et al*., 1989).

The coastal water of Teluk Kemang (Port Dickson) seagrass bed is characterized by high turbidity, resulting in a rapid decline in light with increasing depth. In this area, seagrass *T. hemprichii* only growing in intertidal zone with the coexistence of macro algae and other seagrasses such as *Cymodocea serrulata* and *Halophila ovalis* and never found with seagrass *Halophila decipiens* and big leaves variant *Halophila ovalis* at deeper (≥ 4 m HWL) area (Japar *et al*., 1995; AbuHena *et al*., 1999 and Lee, 1999). Therefore, it is assumed that light availability is a contributing factor that controls the penetration of *T. hemprichii* in deeper area in this seagrass bed. Hence, determination of photosynthesis in different light regimes is of ecological importance. In present study, the photosynthetic and respiration responses of this seagrass species were investigated at different depths and lights in order to evaluate the possible contribution of light in this seagrass bed. Through this experiment the depth distribution of *T. hemprichii* in seagrass bed can also be predicted.

Materials and Methods

Study Area: The study was conducted at Teluk Kemang, Port Dickson coastal area (2°27' N latitude and 101° 51' longitudes) on July 1999. This is an inshore tidal area along the straits of Malacca, in which shallow surrounding platform (≥ 0.2 m HSLW) are covered by mixed and monospecific seagrass patches in sandy muddy bottom substrate with rubble.

Photosynthesis and respiration study in the field: *T. hemprichii* photosynthesis and respiration were conducted *in situ* with the natural light and dark conditions at different depths in the study area. Seagrass shoots were collected and placed in a glass cylinder of 30 cm long x 2.6 cm diameter and filled with seawater. The cylinder mouths were closed with a rubber stopper ensuring that no air bubbles were present. Some of the cylinders were wrapped with aluminum foil to generate the dark condition for dark respiration. Seawater from the study area was used for both light and dark cylinders. Three replicates were used at each depth for both photosynthesis and respiration measurements. Other glass cylinders were used as blanks including seawater without plants to detect the water photosynthesis and respiration by phytoplankton and bacterial activity. All cylinders were incubated at 0.5 m and 2.0 m depth. After incubation for 3 hours, the oxygen produced or consumed was detected by oxygen electrode methods (Rank Brothers, UK). The net photosynthesis and respiration were calculated as in gm fresh weight and cm^2 of leaf surface area after deduction from control values. Light intensity was measured at mid-day with a light sensor (LICOR Model 189, USA) at 0.5 m interval to a depth of 2.0 m.

Laboratory photosynthesis experiment in different light regimes: Plant material of *T. hemprichii* was collected from intertidal seagrass bed of the study area and transported for laboratory experiment. For light response of photosynthetic study, experiment was carried out in the laboratory immediately after collection of specimens. About 1.5 to 2.0 cm long leaf segments were placed in cuvet chamber. The oxygen produced by photosynthesis was detected by oxygen sensor through a recorder (Walker, 1988). Five replicates were used for this detection and the mean value was used.

Irradiances ranging from 20-1600 μmol/m^2/s were provided by 250 watt halogen lamp by adjusting the distance of light source to the chamber. Temperature was maintained at 28°C by circulating the water through outlet jacket of the

chamber. The photosynthetic rate was calculated in g fresh weight, cm^2 of leaf area and mg chlorophyll content. Total chlorophyll content was detected by the procedure described by Arnon (1949). Seagrass leaf was placed in 10 ml of 85% acetone under dark conditions until the colour become totally faded. The volume of acetone is maintained at 10 ml if the initial amount of acetone decreased by evaporation from the preserved test tube. Absorbance was taken for 645 nm and 663 nm by spectrophotometer. Total chlorophyll content was calculated by the following formula:

Total chlorophyll content = 20.2 x A645 + 8.02 x A663 mg/l

Results and Discussion

Photosynthesis and respiration study in the field: The light intensity at different depths during this experimental period is shown in Table 1. The surface light was recorded 1095.43 ± 5.80 $\mu mol/m^2/s$ and decreased to 115.00 ± 1.51 $\mu mol/m^2/s$ at 2.0 meter depth. It is also important to note that the light attenuation was found linearly correlated (Y= -497.57X + 1096, r^2 = 0.999, $p < 0.05$) with the depth to 2.0 m below water surface during the study period. Generally, this kind of symptom exists in the sea, open ocean or any water bodies. The photosynthesis and respiration rates of seagrass *T. hemprichii* are shown in Table 2. The photosynthetic rate based on fresh leaf tissue and leaf surface area was 0.429 ± 0.086 $mgO_2/hr/g$ fr wt and 0.861 ± 0.087 $\mu gO_2/hr/cm^2$ area at 0.5 m depth, respectively. Photosynthetic rate measured from the fresh leaf tissue of *T. hemprichii* showed non-significant difference (t-test, $p > 0.05$) at two depths.

Table 1: *In situ* recorded light intensity during study period from seagrass bed water (during high tide)

Depth (meter)	Light intensity ($\mu mol/m^2/s$)
0.0	1095.430 ± 5.803
0.5	857.967 ± 1.633
1.0	592.933 ± 4.583
1.5	330.967 ± 2.840
2.0	115.000 ± 1.512

Table 2: Photosynthesis and respiration rate at different depths of seagrass *(T. hemprichii)*.

Depth (m)	Photosynthesis rate	Respiration rate	Pn/R
	Based on fresh weight of leaf tissue (mg O_2/hr/g fr wt)		
0.5	0.429 ± 0.086	0.115 ± 0.005	3.73
2.0	0.289 ± 0.034	0.164 ± 0.021	1.76
	Based on leaf surface area ($\mu g\ O_2$/hr/cm ^{2} area)		
0.5	0.861 ± 0.087	0.237 ± 0.074	3.633
2.0	0.540 ± 0.175	0.294 ± 0.093	1.836

However, it differed significantly (t-test, $p < 0.05$) between two depths for the photosynthetic rate of leaf surface area. Comparing between the two depths, the higher photosynthetic rate for *T. hemprichii* at 0.5 m could be attributed to the relatively higher light intensity than at 2.0 m. Basically, photosynthesis is the primary and most important step in the ecological cycle of the sea upon which all other marine plants ultimately depend for energy and carbon source. Thus, light is a fundamentally important entity and essential source of energy for photosynthesis and as well as productivity and growth of all green plants like seagrass. From this experiment it may be assumed that the rate of photosynthesis of *T. hemprichii* at any depth could be expected to vary due to tidal cycle. However, *T. hemprichii* may produce higher oxygen during low tide compared with the high tide.

In contrast, respiration rates of this species for both fresh leaf tissue and leaf surface area values showed little variation (t-test, $p > 0.05$) between the two depths (Table 2). Respiration remains approximately the same, provided that temperature and other factors are essentially unchanged (Clarke, 1967), which support the present findings. The normal oxygen requirement for respiration of *T. hemprichii* was lower than the

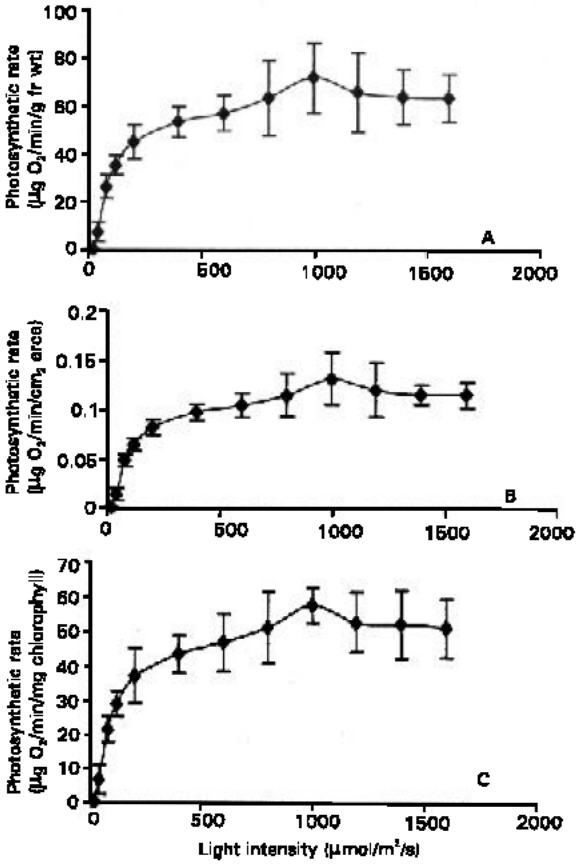

Fig. 1: Photosynthesis rate of seagrass *T. hemprichii* at different light intensities, based on fresh weight (A), based on leaf surface area (B) and based on chlorophyll content (C).

Halophila stipulacea (0.20 mg O_2/hr/g; Wahbeh, 1983) and *C. serrulata* (0.189 ± 0.017 - 0.214 ± 0.014 mg O_2/hr/g fr wt; AbuHena *et al.*, 2001). The respiration rates for other seagrasses *H. ovalis* and *Halodule uninervis* were recorded as 0.92 ± 0.13 and 0.34 ± 0.13 mg O_2/hr/g (Wahbeh, 1983) that required more oxygen than the seagrass *T. hemprichii* for respiration. The photosynthesis and respiration ratio (i.e. productivity index) was found higher in seagrass *T. hemprichii* (Pn/R = 1.76 - 3.73) than seagrass *C. serrulata* (Pn/R = 1.360 - 2.518; AbuHena, *et al.*, 2001). Therefore, the production of the seagrass *T. hemprichii* could probably be higher than *C. serrulata* in the prevailing environment at the study area seagrass bed.

Laboratory study of photosynthesis: Laboratory photosynthesis study of *T. hemprichii* showed that the rate of oxygen evolution increased sharply with the increase in light intensity from 40 - 200 $\mu mol/m^2/s$ (Fig. 1A, B and C). Thereafter, the oxygen evolution increased gradually to relatively constant oxygen production at an average of 50-70 μgO_2/min/g fr wt. Oxygen gain was not detected at light intensity below 20 $\mu mol/m^2/s$.

The compensation light intensity of *T. hemprichii* (the light intensities at which the respiration equals the photosynthesis) was found around 20 $\mu mol/m^2/s$. Light intensities below this value, photosynthesis may still go on but the seagrass is fighting a losing battle. In this condition the seagrass cannot

survive because the loss of energy due to catabolic processes represented by respiration exceed the gain in energy brought by anabolic process of photosynthesis. The compensation light intensity of the present study was comparable with the value of other seagrass in other area (Dennison, 1987; Beer and Waisel, 1982; Dennison and Alberte, 1985). On the other hand, water temperature has been reported as a controlling factor of seagrass respiration (Buesa, 1974; Bulthuis, 1987), and consequently the compensation light intensity. Pollard and Greenway (1993) stated that high compensation light intensities were due to high respiration demand of the plants, which resulted from the high water temperature. They found that the light compensation points were 80 to 90 μmol/m^2/s for the seagrass *Cymodocea serrulata*, *Thalassia hemprichii* and *Zostera capricorni* in Australian seagrass bed, which are higher in comparison with present study at 28° C.

The light response of *T. hemprichii* showed an increased photosynthesis, corresponding with increasing light intensity at 40 – 400 μmol/m^2/s. Beyond this, the photosynthesis showed light saturation trend (Fig. 1A, B and C). No significant difference in photosynthesis was observed with increasing light intensity from 400 to 1600 μmol/m^2/s. Photo inhibition was not observed at light intensity up to 1600 μmol/m^2/s.

The light intensity measured in field during the earlier experiment at the surface was well within light saturation range in this experiment. The photosynthesis probably proceeds at light saturation rate at 0.5 m depth in the field experiment. However, the seagrass *T. hemprichii* could be over exposed to the light especially during clear shiny mid day spring low tide period. Thus, photoinhibition could not be ruled out. The depth gradient light intensity data from the seagrass bed showed that light intensity at 2.0 m depth was higher ($< 115 \pm 1.512$ μmol/m^2/s) than compensation light intensity in the experimental photosynthesis study. Therefore, it may be assumed that the seagrass *T. hemprichii* could penetrate or grow to the deep water with *H. decipiens* and big leaves variant of *H. ovalis* in this study area. But, at present study area the limited intertidal distribution of *T. hemprichii* could be due to environmental factors i.e. current movement, water visibility and sediment status. Either, the photosynthesis proceed at light intensity below 2.0 m depth probably could not support the requirement during dark period, albeit lower light compensation (± 20 μmol/m^2/s) showed in this experimental study.

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