



UNIVERSITI PUTRA MALAYSIA

**SHADING RESPONSES OF THE SEAGRASS
HALOPHILA OVALIS (R. BR.) HOOK. F. FROM
TELUK KEMANG, NEGRI SEMBILAN, MALAYSIA**

MOHAMMAD ROZAIMI B JAMALUDIN

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By

MOHAMMAD ROZAIMI B JAMALUDIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra
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Science

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June 2008

Chairman: Japar Sidik Bujang, PhD

Faculty: Science

The seagrass *Halophila ovalis* from Teluk Kemang coast (2 ° 30'N, 101 ° 45'E) in Port Dickson, Negeri Sembilan was studied to elucidate its responses towards artificial shading. Responses were firstly based on autotrophic productivity of *H. ovalis* through photosynthesis experiments to determine the effects of prior acclimation to the condition of either in the field (naturally growing) or in cultures (light reduced to 85-90% of ambient conditions). Results showed that the light compensation values in field and cultured leaves (8-13 $\mu\text{mol m}^{-2} \text{s}^{-1}$) were similar while saturation point was in the range of 268-275 $\mu\text{mol m}^{-2} \text{s}^{-1}$ for field leaves and increased to 290-293 $\mu\text{mol m}^{-2} \text{s}^{-1}$ for cultured leaves. A one-month long artificially imposed shading was then performed to plants in the field (50%, 65%, 80% and 95% shading relative to field light intensity) and in cultures (92% shading – Tank 1, and 96% shading – Tank 2, relative to field light intensity) and compared to unshaded plants as a control showed the following responses. Photosynthetic rates of field *H. ovalis* at two tide levels as determined using



the Biological Oxygen Demand bottle method was up to six times higher when compared to the oxygen electrode method. Leaf chlorophyll content was significantly higher from plants under shading for both field and cultured leaves compared to control where leaves from cultures (Tank 2) showed the highest value in leaf chlorophyll content ($1353.40 \pm 74.00 \mu\text{g chlorophyll } a \text{ g}^{-1}$, $p < 0.01$, and $11.92 \pm 0.59 \mu\text{g chlorophyll } a \text{ cm}^{-2}$, $p < 0.01$, by leaf fresh weight and leaf surface area respectively, and $744.30 \pm 46.55 \text{ chlorophyll } b \text{ g}^{-1}$, $p < 0.01$ and $6.56 \pm 0.39 \mu\text{g chlorophyll } b \text{ cm}^{-2}$, $p < 0.01$, by leaf fresh weight and leaf surface area respectively). For carbohydrates, starch and the reducing sugars of glucose, sucrose, fructose and maltose were tested for in the below-ground portions of field plants, and above-ground and below-ground portions of cultured plants. Starch was not detected in both above-ground and below-ground plant portions of both field and culture studies. Glucose content was highest among the four sugars, in both field and culture plants but not significantly different compared to the control. Changes in growth rates were the most discernible where increased shading results in decreased growth rates ($3.72 \pm 0.51 \text{ mm apex}^{-1} \text{ day}^{-1}$ from control plants, to the significantly lowest recorded growth rate value of $0.746 \pm 0.205 \text{ mm apex}^{-1} \text{ day}^{-1}$, $p < 0.01$, from Tank 1 plants). Leaf morphology based on leaf length, leaf width, leaf petiole length, number of cross veins per leaf, leaf fresh weight and leaf surface area were significantly higher for leaves under shading in culture condition compared to field-shaded leaves and the control. This is substantiated by the data from Tank 2 where leaf length is $24.73 \pm 0.54 \text{ mm}$, leaf width – 9.38 ± 0.23 , leaf length-width ratio – 2.80 ± 0.030 , leaf petiole length – 28.48 ± 1.03 , leaf cross vein number – 14.47 ± 0.27 , leaf



fresh weight – 0.0179 ± 0.00134 and leaf surface area – 2.011 ± 0.126) compared to the unshaded control (leaf length: 13.20 ± 0.54 mm; leaf width: 6.81 ± 0.29 ; leaf length-width ratio: 1.93 ± 0.037 ; leaf petiole length: 11.20 ± 1.43 ; leaf cross vein number: 11.40 ± 0.35 ; leaf fresh weight: 0.00680 ± 0.000548 ; and leaf surface area: 0.796 ± 0.0744). For field biomass values, there were no significant differences between shaded plants and the control. Comparatively, culture biomass values of Tank 1 were significantly higher for both above-ground biomass (0.0127 ± 0.00238 g DW rhizome⁻¹, $p < 0.01$) and below-ground biomass (0.0282 ± 0.00245 g DW rhizome⁻¹, $p < 0.01$) compared to the unshaded control (0.0107 ± 0.000914 g DW rhizome⁻¹ and 0.0192 ± 0.00109 g DW rhizome⁻¹ for above-ground and below-ground biomass respectively). All the observations and results collated showed *H. ovalis* tolerates extreme low light conditions as low as 96% shading ($80 \mu\text{mol m}^{-2} \text{s}^{-1}$) by modifying its various physical and biochemical characteristics accordingly with its light environment. This is also evident that the plant survives and continues to maintain productivity with respect to photosynthesis and carbohydrate production even under the highest shading levels imposed in both field (95% shading) and cultures (Tank 2 – 96% shading). Furthermore, it is possible to culture *H. ovalis*, although maximum growth densities equivalent to those observed in the field were not achieved. The findings suggest that lowered light availability may not be the sole causal factor for *H. ovalis* loss in a particular area. Other aspects such as epiphytic fouling and available nutrients could be more important in the loss of *H. ovalis* vegetation, although an interaction of the factor of reduced light and these other factors should not be discounted.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master of Science

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TELUK KEMANG, NEGERI SEMBILAN, MALAYSIA**

Oleh

MOHAMMAD ROZAIMI B JAMALUDIN

Jun 2008

Pengerusi: Japar Sidik Bujang, PhD

Fakulti: Sains

Kajian terhadap *Halophila ovalis* dari Teluk Kemang (2 ° 30'N, 101 ° 45'E), Port Dickson, Negeri Sembilan telah dibuat untuk melihat tindakbalas rumput laut ini kepada keredupan tiruan. Tindakbalas berdasarkan produktiviti autotrofik *H. ovalis* melalui beberapa eksperimen fotosintesis adalah untuk mengenalpasti kesan adaptasi tumbuhan kepada di lapangan (pertumbuhan semulajadi) atau di dalam kultur (cahaya dikurangkan ke 85-90% dari keamatan cahaya semulajadi). Hasil pemerhatian mendapati nilai kepampasan cahaya adalah tidak berbeza di antara daun dari lapangan atau daun dari kultur (8-13 $\mu\text{mol m}^{-2} \text{s}^{-1}$). Manakala titik ketepuan cahaya adalah berada dalam lingkungan 268-275 $\mu\text{mol m}^{-2} \text{s}^{-1}$ bagi daun dari lapangan dan nilai titik ketepuan cahaya bagi daun dari kultur meningkat ke lingkungan 290-293 $\mu\text{mol m}^{-2} \text{s}^{-1}$. Kajian selama satu bulan telah dibuat terhadap tumbuhan di lapangan (tahap 50%, 65%, 80% dan 95% daripada intensiti cahaya lapangan) dan di dalam kultur (keredupan 92% pada Tangki 1 dan 96% keredupan pada Tangki 2) berbanding dengan kawalan tanpa keredupan



cahaya. Kadar fotosintesis *H. ovalis* di lapangan pada aras air surut dan pasang sederhana dan juga daripada kultur berdasarkan kaedah botol 'Biological Oxygen Demand' adalah sehingga enam kali lebih tinggi dari nilai yang didapati melalui kaedah elektrod oksigen. Kandungan klorofil pada daun tumbuhan di lapangan dan kultur yang diredupkan adalah lebih tinggi berbanding dengan kawalan di mana daun dari kultur (Tangki 2) menunjukkan nilai kandungan klorofil tertinggi ($1353.40 \pm 74.00 \mu\text{g}$ klorofil *a* g^{-1} , $p < 0.01$ bagi berat daun segar, dan $11.92 \pm 0.59 \mu\text{g}$ klorofil *a* cm^{-2} , $p < 0.01$, bagi kawasan permukaan daun, serta 744.30 ± 46.55 klorofil *b* g^{-1} , $p < 0.01$ bagi berat daun segar dan $6.56 \pm 0.39 \mu\text{g}$ klorofil *b* cm^{-2} , $p < 0.01$, bagi kawasan permukaan daun). Untuk kandungan karbohidrat, kanji dan empat jenis gula – glukos, sukros, fruktos dan maltos telah diuji pada bahagian tumbuhan yang di atas permukaan substrat ("above-ground") dan di bawah substrat ("below-ground") untuk di lapangan dan kultur. Kanji tidak dikesan pada kedua-dua bahagian tumbuhan "above-ground" dan "below-ground" untuk tumbuhan di lapangan dan kultur. Kandungan glukos adalah yang tertinggi berbanding gula yang lain tetapi nilainya tidak jauh berbeza dengan tumbuhan kawalan. Analisis kadar pertumbuhan telah menunjukkan nilai perbezaan yang paling ketara di mana didapati peningkatan kadar keredupan menyebabkan penurunan kadar pertumbuhan (pertumbuhan sebanyak $3.72 \pm 0.51 \text{ mm apex}^{-1} \text{ hari}^{-1}$ bagi tumbuhan kawalan berbanding dengan tumbuhan pada Tangki 1 yang menunjukkan rekod nilai pertumbuhan yang paling rendah iaitu pada $0.746 \pm 0.205 \text{ mm apex}^{-1} \text{ hari}^{-1}$, $p < 0.01$). Morfologi daun berdasarkan parameter kepanjangan daun, kelebaran daun, nisbah panjang-kelebaran daun, kepanjangan 'petiole' daun,



jumlah 'cross veins' untuk sehelai daun, berat daun segar, dan luas permukaan daun di dalam keadaan keredupan di lapangan dan kultur menunjukkan nilai kesemua parameter-parameter ini adalah lebih tinggi berbanding tumbuhan kawalan. Ini disokong oleh data dari Tangki 2 di mana panjang daun adalah 24.73 ± 0.54 mm, kelebaran daun – 9.38 ± 0.23 , nisbah panjang-kelebaran daun – 2.80 ± 0.030 , kepanjangan 'petiole' daun – 28.48 ± 1.03 , jumlah 'cross vein' daun – 14.47 ± 0.27 , berat daun segar – 0.0179 ± 0.00134 dan kawasan permukaan daun – 2.011 ± 0.126 jika dibandingkan dengan tumbuhan kawalan (panjang daun: 13.20 ± 0.54 mm; kelebaran daun: 6.81 ± 0.29 ; nisbah panjang-kelebaran daun: 1.20 ± 1.43 ; kepanjangan 'petiole' daun: 11.40 ± 0.35 ; jumlah 'cross vein' daun: 14.47 ± 0.27 ; berat daun segar: 0.00680 ± 0.000548 ; dan kawasan permukaan daun: 0.796 ± 0.0744). Bagi nilai biojisim, tiada perbezaan ketara antara tumbuhan yang diredup di lapangan dan tumbuhan kawalan. Secara bandingan, nilai biojisim bagi tumbuhan dari Tangki 1 adalah lebih tinggi (0.0127 ± 0.00238 g DW rhizome⁻¹, $p < 0.01$, bagi bahagian di atas permukaan substrat dan 0.0282 ± 0.00245 g DW rhizome⁻¹, $p < 0.01$, bagi bahagian di bawah substrat) berbanding tumbuhan kawalan (0.0107 ± 0.000914 g DW rhizome⁻¹ bagi bahagian di atas permukaan substrat dan 0.0192 ± 0.00109 g DW rhizome⁻¹ bagi bahagian di bawah substrat). Berdasarkan kesemua pemerhatian dan hasil tinjauan yang telah dijalankan, didapati *H. ovalis* adalah toleran kepada keadaan keamatan cahaya yang rendah di mana tumbuhan ini melalui perubahan secara fizikal dan biokimia, mengikut kedapatan cahaya di persekitarannya. Ini juga terbukti bahawa tumbuhan ini mampu hidup dan mengekalkan produktiviti walaupun pada tahap keredupan yang tinggi, iaitu

sebanyak 95% keredupan di lapangan dan sebanyak 96% keredupan di dalam kultur (Tangki 2). Adalah tidak mustahil untuk mengkulturkan *H. ovalis*, walaupun kadar maksimum bagi kepadatan pertumbuhan seperti tumbuhan di lapangan tidak tercapai. Hasil kajian ini memperlihatkan bahawa kerendahan terdapat cahaya bukan hanya faktor yang menyebabkan kehilangan *H. ovalis* di sesuatu kawasan. Aspek-aspek lain seperti “epiphytic fouling” dan kepadatan nutrien berinteraksi dengan faktor kurangnya terdapat cahaya perlu diambil kira juga.



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I certify that an Examination committee has met on the **12th of June, 2008** to conduct the final examination of **Mohammad Rozaimi b Jamaludin** on his **Master of Science** thesis entitled "**Shading responses of the seagrass *Halophila ovalis* (R. Br.) Hook. f. from Port Dickson, Negri Sembilan, Malaysia**" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and the Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the Master of Science.

Members of the Examination Committee were as follows:

Aziz Arshad, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Umi Kalsom Yusuf, PhD
Professor
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Abdul Rahim Ismail, PhD
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Phang Siew Moi, PhD
Professor
Faculty of Science
University of Malaya
Malaysia
(External Examiner)

HASANAH MOHD. GHAZALI, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:



This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of **Master of Science**. The members of the Supervisory committee were as follows:

Japar Sidik Bujang, PhD

Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Misri Kusnan, PhD

Faculty of Science
Universiti Putra Malaysia
(Member)

Hishamuddin Omar, PhD

Faculty of Science
Universiti Putra Malaysia
(Chairman)

AINI IDERIS, PhD

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 14 August 2008



DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

MOHAMMAD ROZAIMI B JAMALUDIN

Date: 8th July 2008



TABLE OF CONTENTS

		Page
ABSTRACT		iii
ABSTRAK		vi
ACKNOWLEDGEMENTS		x
APPROVAL		xi
DECLARATION		xiii
LIST OF TABLES		xvii
LIST OF FIGURES		xx
LIST OF ABBREVIATIONS		xxiv
CHAPTER		
1	GENERAL INTRODUCTION	1
2	LITERATURE REVIEW	5
	Seagrasses and their distributions	5
	Seagrasses from Malaysia	7
	Importance of seagrasses and the threats to its existence	10
	Light attenuation in the sea and its effects on seagrasses	19
	Physiological responses to light reduction by shading	28
	<i>Halophila ovalis</i>	33
3	PHOTOSYNTHETIC LIGHT RESPONSES OF NATURALLY GROWING AND CULTURED <i>HALOPHILA OVALIS</i>	38
	Abstract	38
	Introduction	39
	Materials and methods	42
	Plant material	42
	Experimental mechanism	43
	Leaf parameters	44
	Graphical analyses	45
	Statistical analyses	46
	Results	46
	Discussions	50
4	<i>IN SITU</i> RESPONSES OF <i>HALOPHILA OVALIS</i> TOWARDS SHADING	57
	Abstract	57
	Introduction	59
	Materials and Methods	63
	Study site	63
	Shading apparatus	65
	Analyses of plant material	67
	Photosynthetic rates	68
	Chlorophyll content	69
	Carbohydrate content	69
	Plant growth rates	70



	Leaf morphological measurements	70
	Plant biomass	71
	Statistical analyses	71
Results		72
	Photosynthetic rates	72
	Mean photosynthetic rates based on leaf fresh weight	73
	Mean photosynthetic rates based on leaf surface area	76
	Mean photosynthetic rates based on leaf chlorophyll content	77
	Chlorophyll content	79
	Mean chlorophyll <i>a</i> content	81
	Mean chlorophyll <i>b</i> content	82
	Mean ratio of chlorophyll <i>a</i> to chlorophyll <i>b</i>	84
	Carbohydrate content	84
	Mean glucose content	87
	Mean sucrose content	87
	Mean fructose content	88
	Mean maltose content	88
	Plant growth rates	89
	Leaf morphological measurements	89
	Mean leaf length	91
	Mean leaf width	91
	Mean leaf length to width ratio	93
	Mean leaf petiole length	93
	Mean number of leaf cross-veins	95
	Mean leaf fresh weight	95
	Mean leaf surface area	97
	Plant biomass	97
	Above-ground biomass	99
	Below-ground biomass	99
	Above-ground to below-ground biomass ratio	101
Discussions		101
5	RESPONSES OF <i>HALOPHILA OVALIS</i> TOWARDS SHADING IN CULTURES	120
	Abstract	120
	Introduction	122
	Materials and Methods	126
	Plant source	136
	Plant material and shading setup	127
	Analyses of plant material	132
	Leaf chlorophyll content and leaf morphology	132
	Above-ground versus below ground biomass and ratios	133
	Carbohydrate content	133
	Statistical analyses	135



Results	135
Photosynthesis rates	136
Mean photosynthetic rates based on leaf fresh weight	136
Mean photosynthetic rates based on leaf surface area	138
Mean photosynthetic rates based on leaf chlorophyll content	138
Chlorophyll content	140
Mean chlorophyll <i>a</i> content	140
Mean chlorophyll <i>b</i> content	144
Mean ratio of chlorophyll <i>a</i> to chlorophyll <i>b</i>	146
Carbohydrate content	148
Mean glucose content	150
Mean sucrose content	150
Mean fructose content	151
Mean maltose content	152
Plant growth rates	152
Leaf morphological measurements	153
Mean leaf length	153
Mean leaf width	155
Mean leaf length to width ratio	157
Mean leaf petiole length	157
Mean number of leaf cross-veins	159
Mean leaf fresh weight	160
Mean leaf surface area	162
Above-ground and below ground plant biomass	163
Mean above-ground and below-ground biomass	163
Mean ratio of above-ground to below-ground biomass	165
Discussions	167
6 GENERAL DISCUSSIONS	180
Basics of seagrass shading	180
Study descriptions	181
Various responses of <i>H. ovalis</i> to shading	194
7 CONCLUSION	216
REFERENCES	218
APPENDIX 1 – EXPERIMENTAL METHODS	237
APPENDIX 2 – DATA VALUES	244
APPENDIX 3 – REGRESSION ANALYSIS OF FIELD EXPERIMENTS	272
BIODATA OF THE AUTHOR	282
LIST OF PUBLICATIONS PRODUCED	283



LIST OF TABLES

No.	Table	Page
1	Functions and values of seagrass from the wider ecosystem perspective.	13
2	Characteristic differences between plants adapted or acclimated to sunny versus shady extremes in irradiance level.	32
3	Summary of the photosynthetic rates (R_{dark} , I_c , I_k and P_{max} values) inferred from their respective curves.	51
4	Photosynthetic irradiance values (I_c and I_k) and its corresponding plant part used from selected <i>Halophila</i> by exposure to graded light regimes.	52
5	Comparisons of the photosynthetic rates between the method used in Chapter 3 (oxygen electrode method) and that used in this chapter (BOD incubations).	104
6	Comparisons of the photosynthetic rates between the method used in Chapter 3 (oxygen electrode method) and that used in this chapter (BOD incubations).	169
7a	Summary of the photosynthetic rates of field and cultured <i>Halophila ovalis</i> as recorded through oxygen electrode incubation.	195
7b	Summary of the photosynthetic rates of field and cultured <i>Halophila ovalis</i> as recorded through biological oxygen demand (BOD) bottle incubation method.	196
8	Summary of the chlorophyll content of field and cultured <i>Halophila ovalis</i> .	197
9a	Summary of starch content of field and cultured <i>Halophila ovalis</i> .	198
9b	Summary of sugar content of field and cultured <i>Halophila ovalis</i> .	199
10	Summary of growth rates of field and cultured <i>Halophila ovalis</i> .	200
11a	Summary of the morphology (leaf length, leaf width, leaf length to width ratio and leaf petiole length) of field and cultured <i>Halophila ovalis</i> .	201
11b	Summary of the morphology (leaf cross-vein number, leaf fresh weight and leaf surface area) of field and cultured	202



Halophila ovalis.

12a	Summary of the biomass of field and cultured <i>Halophila ovalis</i> .	203
12b	Summary of above-ground to below-ground biomass ratio.	204
13	Photosynthetic rates ($\bar{x} \pm$ S. E.) of <i>Halophila ovalis</i> based on leaf fresh weight (13a), leaf surface area (13b) and leaf chlorophyll content (13c).	244
14a	Values of mean photosynthesis rates at low tide level.	245
14b	Values of mean photosynthesis rates at moderate tide level.	246
15a	Values of mean chlorophyll <i>a</i> content relative to the respective parameters.	247
15b	Values of mean chlorophyll <i>b</i> content relative to the respective parameters.	247
15c	Table 15c. Mean ratio value of chlorophyll <i>a</i> to <i>b</i> content.	248
16	Values of mean sugar content (glucose, sucrose, fructose and maltose).	249
17	Mean values of the growth rates of <i>Halophila ovalis</i> rhizomes from the four shading grades and control.	250
18	Mean values of the morphological measurements from the parameters of leaf length, leaf width, leaf length to width ratio, leaf petiole length, number of leaf cross-veins, leaf fresh weight and leaf surface area.	251
19a	Mean values of above-ground biomass.	253
19b	Mean values of below-ground biomass	253
19c	Mean value of the ratio of above-ground to below-ground biomass.	253
20	Photosynthesis rates from the parameters of leaf fresh weight (20a), leaf surface area (20b) and leaf chlorophyll amount (20c).	254
21	Chlorophyll <i>a</i> content (21a-i, ii), chlorophyll <i>b</i> content (21b-i, ii) and chlorophyll <i>a</i> to <i>b</i> ratios (21c) from culture shadings.	257
22	Values of mean glucose (Table 22a), sucrose (Table 22b), fructose (Table 22c) and maltose (Table 22d) content.	262



23	Mean values of the growth rates of <i>Halophila ovalis</i> from cultures.	266
24	Mean morphological measurements from the parameters of leaf length, leaf width (Table 24a), leaf length to width ratio, leaf petiole length (Table 24b), number of leaf cross-veins, leaf fresh weight (Table 24c) and leaf surface area (Table 24d).	267
25	Mean values of above-ground and below-ground plant biomass (25a) and the mean ratio value of above-ground and below-ground biomass (25b).	271



LIST OF FIGURES

No.	Figure	Page
1	The major and important seagrass areas, associated habitats, utilization by coastal communities and other users in Peninsular Malaysia (A) and East Malaysia – Sabah (A) and Sarawak (C).	11
2	Depth limits compiled for 31 marine angiosperm species.	22
3	<i>Halophila ovalis</i> population in Teluk Kemang.	23
4	<i>Ulva</i> sp. canopy upon <i>Halophila ovalis</i> at Tanjung Chek Jawa, Singapore.	25
5	<i>Halophila ovalis</i> from Teluk Kemang covered with epiphytes.	25
6	Theoretical progression of a photosynthesis-irradiance (P-I) curve.	29
7	Comparisons of photosynthetic parameters of some studied seagrasses.	31
8	Botanical classification of <i>Halophila ovalis</i> .	35
9	Key to the species from section <i>Halophila</i> .	35
10	World geographical distribution of <i>Halophila ovalis</i> .	36
11a	Photosynthetic rates ($\bar{x} \pm S. E.$) based on leaf fresh weight by the oxygen electrode method.	47
11b	Photosynthetic rates ($\bar{x} \pm S. E.$) based on leaf surface area by the oxygen electrode method.	47
11c	Photosynthetic rates ($\bar{x} \pm S. E.$) based on leaf chlorophyll content by the oxygen electrode method	48
12	Location of the study site at Teluk Kemang (2 ° 30 ' N, 101 ° 45 ' E).	64
13	Shading frames staked upon the seabed in Teluk Kemang.	66
14	Some of the shading frames used for the field shading experiments at Teluk Kemang.	66
15a	Photosynthetic rate ($\bar{x} \pm S. E.$) of leaves from field by leaf fresh weight (FW).	75
15b	Photosynthetic rate ($\bar{x} \pm S. E.$) of leaves from field by leaf surface area (Area).	78



15c	Photosynthetic rate ($\bar{x} \pm$ S. E.) of leaves from field by leaf chlorophyll content (Chl).	80
16a	Mean of chlorophylls <i>a</i> and <i>b</i> ($\bar{x} \pm$ S. E.) of leaves from field samples by leaf fresh weight (FW).	83
16b	Mean of chlorophylls <i>a</i> and <i>b</i> ($\bar{x} \pm$ S. E.) of leaves from field samples by leaf surface area (Area).	83
16c	Mean of ratio ($\bar{x} \pm$ S. E.) of chlorophyll <i>a</i> to <i>b</i> of leaves from field samples.	85
17	Mean content of reducing sugars ($\bar{x} \pm$ S. E.) in below-ground plant portions per gram of dried field samples.	86
18	Mean values of the growth rate ($\bar{x} \pm$ S. E.) of <i>Halophila ovalis</i> rhizomes from the four shading grades and control.	90
19a	Mean length of leaves ($\bar{x} \pm$ S. E.) from field samples.	91
19b	Mean width of leaves ($\bar{x} \pm$ S. E.) from field samples.	91
19c	Mean ratio ($\bar{x} \pm$ S. E.) of leaf length to width of field samples.	94
19d	Mean petiole length of leaves ($\bar{x} \pm$ S. E.) from field samples.	94
19e	Mean number of cross-veins ($\bar{x} \pm$ S. E.) of leaves from field samples.	96
19f	Mean fresh weight of leaves ($\bar{x} \pm$ S. E.) from field samples.	96
19g	Mean surface area of leaves ($\bar{x} \pm$ S. E.) from field samples.	98
20a	Above-ground and below ground biomass ($\bar{x} \pm$ S. E.) of field samples	100
20b	Mean of ratio ($\bar{x} \pm$ S. E.) of above-ground biomass to below ground biomass of field samples	100
21a	Theoretical diagram on the energy level flow during photosynthesis.	108
21b	Components of the antenna proteins involved in photosynthesis.	108
22a	Evidence of grazing on <i>H. ovalis</i> leaves by <i>Clithon</i> sp. (arrow).	129
22b	<i>Clithon</i> sp. that grazes on <i>H. ovalis</i> leaves.	129
23a	Sporobid polychaete fouling on <i>H. ovalis</i> leaves.	130



23b	The spirorbid polychaetes attached to <i>H. ovalis</i> leaf as observed under a light microscope.	130
24	Tank placements layout of the culture shading study.	131
25	Node positions of the leaves taken for analysis.	134
26a	Photosynthetic rate ($\bar{x} \pm S. E.$) of field leaves by leaf fresh weight.	137
26b	Photosynthetic rate ($\bar{x} \pm S. E.$) of field leaves by leaf surface area.	139
26c	Photosynthetic rate ($\bar{x} \pm S. E.$) of field leaves by leaf chlorophyll content.	141
27a	Mean content of chlorophylls <i>a</i> and <i>b</i> ($\bar{x} \pm S. E.$) from culture samples by leaf fresh weight.	143
27b	Mean content of chlorophylls <i>a</i> and <i>b</i> ($\bar{x} \pm S. E.$) from culture samples by leaf surface area.	143
27c	Mean of ratio of chlorophyll <i>a</i> to <i>b</i> ($\bar{x} \pm S. E.$) of leaves from culture.	147
28	Mean content of reducing sugars ($\bar{x} \pm S. E.$) in above and below-ground plant portions per gram of dried leaf cultures.	149
29	Mean growth rate ($\bar{x} \pm S. E.$) of <i>Halophila ovalis</i> from cultures	154
30a	Mean length of leaves ($\bar{x} \pm S. E.$) from cultures.	156
30b	Mean width of leaves ($\bar{x} \pm S. E.$) from cultures.	156
30c	Mean ratio of leaf length to width ($\bar{x} \pm S. E.$) from cultures.	158
30d	Mean petiole length of leaves ($\bar{x} \pm S. E.$) from cultures.	158
30e	Mean number of cross-veins of leaves ($\bar{x} \pm S. E.$) from cultures.	161
30f	Mean fresh weight of leaves ($\bar{x} \pm S. E.$) from cultures.	161
30g	Mean surface area of leaves ($\bar{x} \pm S. E.$) from cultures.	164
31a	Mean values of above-ground and below-ground plant biomass ($\bar{x} \pm S. E.$) from cultures.	166
31b	Mean ratio ($\bar{x} \pm S. E.$) of above-ground and below-ground plant biomass from cultures.	166



32	Basic hypothetical relationships of the parameters under investigations done in Chapters 4 and 5.	184
33	Sucrose and starch biosynthesis and catabolism in plant cells.	189
34	Illustration of the experimental setup used for the photosynthesis analysis by the oxygen electrode method.	238
35	An example of a single sprig of <i>Halophila ovalis</i> used for analyses.	242
36	Curve-fit regression analysis of values obtained in Chapter 4 from field experiments of photosynthesis by leaf fresh weight at low water level (Figure 36a); photosynthesis by leaf surface area at low water level (Figure 36b); and photosynthesis by leaf chlorophyll content at low water level (Figure 36c).	272
37	Curve-fit regression analysis of values obtained in Chapter 4 from field experiments of photosynthesis by leaf fresh weight at moderate water level (Figure 37a); photosynthesis by leaf surface area at moderate water level (Figure 36b); and photosynthesis by leaf chlorophyll content at moderate water level (Figure 37c).	273
38	Curve-fit regression analysis of values obtained in Chapter 4 from field experiments of chlorophyll <i>a</i> content by leaf fresh weight (Figure 38a-i); field experiments of chlorophyll <i>b</i> content by leaf fresh weight (Figure 38a-ii); chlorophyll <i>a</i> content by leaf surface area (Figure 38b-i); field experiments of chlorophyll <i>b</i> content by leaf surface area (Figure 38b-ii); and chlorophyll <i>a</i> to <i>b</i> ratio (Figure 38c).	274
39	Curve-fit regression analysis of values obtained in Chapter 4 from field experiments of glucose content (Figure 39a); sucrose content (Figure 39b); fructose content (Figure 39c) and maltose content (Figure 39d).	276
40	Curve-fit regression analysis of values obtained in Chapter 4 from field experiments of leaf length (Figure 40a); leaf width (Figure 40b); leaf length to width ratio (Figure 40c); leaf petiole length (Figure 40d); leaf cross-vein number (Figure 40e); leaf fresh weight (Figure 40f) and leaf surface area (Figure 40g).	278
41	Curve-fit regression analysis of values obtained in Chapter 4 from field experiments of above-ground biomass (Figure 41a); below-ground biomass (Figure 41b) and above-ground to below ground biomass ratio (Figure 41c).	281



LIST OF ABBREVIATIONS

α	Photosynthetic efficiency
AG	Above-ground
Area	Leaf Surface Area
BG	Below-ground
BOD	Biological Oxygen Demand
Chl	Chlorophyll
DW	Leaf Dry Weight
FW	Leaf Fresh Weight
HPLC	High Performance Liquid Chromatography
I_c	Light compensation point
I_k	Light saturation point
IUCN	The World Conservation Union
KEGG	Kyoto Encyclopedia of Genes and Genomes
LHC	Light-Harvesting Complex
LHC II	Light Harvesting Complex II
NCSS	Number Cruncher Statistical System
PAR	Photosynthetically Active Radiation
P-I	Photosynthesis-Irradiance
P_{max}	Maximal photosynthetic capacity
PS I	Photosystem complex I
PS II	Photosystem complex II
R_{dark}	Dark respiration

