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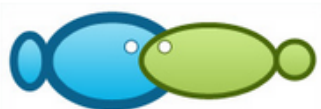
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Mulyono M., Abinawanto, Mardiyono, Syam M. Y., Sudiarsa I. N., 2018 Morphometric and genetic diversity of mantis shrimp *Harpiosquilla raphidea* from Karimata strait and Java Sea waters, Indonesia. AACL Bioflux 11(6):1681-1687.

Khasani I., Krettiawan H., Sopian A., Anggraeni F., 2018 Selection response and heritability of growth traits of giant freshwater prawn (*Macrobrachium rosenbergii*) in Indonesia. AACL Bioflux 11(6):1688-1695.

Afrisal M., Irmawati, Isyrini R., Burhanuddin A. I., 2018 Morphologic and radiographic analyses of *Lethrinus erythropterus* (Lethrinidae) from the Spermonde Archipelago, Indonesia. AACL Bioflux 11(6):1696-1706.

Setyawan A., Isnansetyo A., Murwantoko, Indarjulianto S., Handayani C. R., 2018 Comparative immune response of dietary fucoidan from three Indonesian brown algae in white shrimp *Litopenaeus vannamei*. AACL Bioflux 11(6):1707-1723.

Abinawanto, Wulandari R., Muchlisin Z. A., 2018 Effect of egg yolk on the spermatozoa quality of the botia *Chromobotia macracanthus* (Bleeker, 1852) (Cyprinidae) after short-term cryopreservation. AACL Bioflux 11(6):1737-1744.

Hisam F., Chong M. C., Hajisamae S., Aziz N. A. N., Naimullah M., Hassan M., 2018 Study on effect of hooking location and injuries to the survival of Indonesian snakehead *Channa micropeltes* using treble hook in recreational fishing. AACL Bioflux 11(6):1745-1755.

Burhanuddin A. I., Nurjirana, Afrisal M., Iwatsuki Y., 2018 Distributional notes of the crested hairtail, *Tentoriceps cristatus* (Klunzinger, 1884) from Spermonde Archipelago, South Sulawesi, Indonesia. AACL Bioflux 11(6):1756-1759.

Knaus U., Appelbaum S., Palm H. W., 2018 Significant factors affecting the economic sustainability of closed backyard aquaponics systems. Part IV: autumn herbs and polyponics. AACL Bioflux 11(6):1760-1775.

Hisam F., Hajisamae S., Ikhwanuddin M., Aziz N. A. N., Naimullah M., Hassan M., 2018 Study on the reproductive biology of the blue swimming crab, *Portunus pelagicus* females from Pattali coastal waters, Thailand. AACL Bioflux 11(6):1776-1791.

Mulyani S., Tuwo A., Syamsuddin R., Jompa J., 2018 Effect of seaweed *Kappaphycus alvarezii* aquaculture on growth and survival of coral *Acropora muricata*. AACL Bioflux 11(6):1792-1798.

Rasyid A., Dody S., 2018 Evaluation of the nutritional value and heavy metal content of the dried marine gastropod *Laevistrombus turturella*. AACL Bioflux 11(6):1799-1806.

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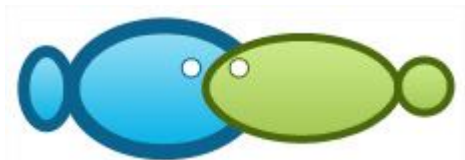
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testing conservation area management effectivity in Indonesia. AAAL Bioflux
11(6):1947-1956.



Effect of high temperature stress on changes in morphology, anatomy and chlorophyll content in tropical seagrass *Thalassia hemprichii*

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Abstract. This study aimed to discover the response of *Thalassia hemprichii* due to high temperature stress treatment (40.5°C). Morphological and anatomical changes of leaf, rhizome and root, and chlorophylls content were investigated. The results showed that morphological changes were organ damage, changes of colors and texture. Anatomical changes were indicated by changes in leaf thickness, size of epidermis and mesophyll tissues in leaf; size of pith, cortex and aerenchyma tissues in rhizome; pith and aerenchyma tissues of root. While the cortex and endodermis tissues of the root did not show any changes. Chlorophyll a, chlorophyll b and total chlorophyll contents significantly declined due to heat stress.

Key Words: heat stress, seagrass, leaf, rhizome, root, chlorophyll.

Introduction. Rising temperature, due to global warming, has not only affected on terrestrial organisms but also on coastal organisms. Heat stress because of high temperatures, could affect whether plant morphology, anatomy, physiology, photosynthetic capability, and genetic expression of plants (Chen et al 2014). Moreover, various physiological changes occur in plants such as scorching of leaves and stems, leaf abscission and senescence, shoot and root growth inhibition (Bita & Gerats 2013; Teixeira et al 2013). Heat stress also affects the photosynthesis, respiration, water relations and membrane stability, and modulates levels of hormones, and primary and secondary metabolites (Hemantaranjan et al 2014).

Seagrasses are key-species in coastal ecosystems, as important primary producers providing food, nursery and shelter for many marine species (Orth et al 2006). However, declining seagrass ecosystem has been reported throughout the both northern and southern hemispheres (Waycott et al 2009). Collier & Waycott (2014) reported that high temperatures during low tide could decline the rate of growth and even induce seagrass mortality. During tidal exposure, intertidal seagrass is susceptible to extreme radiation doses, desiccation, thermal stress and excess light leading to organ damage (Campbell et al 2006). To date, study about seagrass response under heat stress is still limited on temperate seagrass such as *Zostera marina* and *Posidonia oceanica* (Bergmann et al 2010; Marin-Guirao et al 2016). Only few studies have addressed to tropical seagrass.

Thalassia hemprichii (Ehrenb.) Aschers. is among the most widely-distributed seagrass species in the SE Asian region, especially in Indonesian waters (Nienhuis et al 1989; Aswandy & Azkab 2000). It means that *T. hemprichii* is a seagrass endemic to tropical waters so it may be used as an ideal model that could describe the ecological conditions of tropical coastal waters. Nugraha et al (2017) revealed that water temperature in Seribu Islands, where *T. hemprichii* inhabited, reached 34°C. Massa et al

(2009) also reported that the temperature of the shallow water during daylight low tide could reach 38°C. Collier & Waycott (2014) reported the worst record of shallow water temperature. It was 43°C. Nevertheless, the optimal temperature for seagrass to photosynthesis and growth ranges from approximately 30 to 35°C (Pedersen et al 2016). Extreme events occurring during low tide have been linked to seagrass loss (Massa et al 2009; Rasheed & Unsworth 2011).

Study about morphological and anatomical changes become important since limited details and plants with high temperatures stress symptoms are generally similar to those under drought stress. Thus, this study was aimed to determine morphological and anatomical changes of *T. hemprichii* under heat stress. Chlorophylls content also were observed to describe photosynthesis response during heat stress.

Material and Method. The study was conducted from February to May 2018 at Department of Biology, Faculty of Sciences and Technology, Airlangga University. The experiment was performed in hydroponic culture system under aquarium conditions based on adopted methods of Purnama et al (2015). Samples of *T. hemprichii* (10-15 cm from base to tip of leaf) were obtained from the north coast of Lamongan (6°52'40.8"S; 112°12'50.5"E). The experimental design consisted of two groups (heat and normal) replicated ten times in a split plot design. The whole cores including seagrass and rhizosphere sediment were collected to ensure that the samples were complete and undamaged. Then the intact plants were cultured in aerated aquarium (60 x 30 x 40 cm³) filled with 100 L of seawater (salinity 30-33‰) from Kenjeran Beach, Surabaya. Plants of equal size were placed in each of the 2 aquaria. A total of 60 samples of *T. hemprichii* were divided into 2 treatment groups: heat (treatment with thermal stress) and normal (control at ambient temperature). Before heat treatment, seagrass samples were acclimatized for one week in laboratory conditions (light intensity of 250 μmol m⁻² s⁻¹ at temperature of 26±2°C). The temperature in the heat stress treatment aquaria was slowly increased from 28 to 40.5°C (increased 1.5°C d⁻¹ over 8 d). The heat source was obtained from the water heater connected to the digital Thermostat STC 100 to maintain temperature. Seagrass in aquaria without thermal stress kept with each set of experiment as control.

Sample leaf, rhizome and root were collected in last day from both conditions, cleaned from epiphytes and blotted dry using tissue paper. Morphological changes were investigated by describing the appearance, color, texture and presence of organ damage. Anatomical measurements were performed on the fifth fully expanded leaves (numbered from the center), rhizomes and longest roots (measured from rhizome). Samples were prepared for a standard paraffin sectioning according to adapted methods of Purnobasuki et al (2017). They were fixed and preserved in FAA (70% ethanol, 10% formalin, 5% acetic acid - 90:5:5). The air in the tissue was evacuated by oil rotary vacuum pump (Model SW-20, Sato Vacuum Machinery, Japan) for several times. Samples were dehydrated in an ethanol-xylene series (50, 70, 85, 95 and 100% ethanol, ethanol-xylene 1:1, xylene 100%) and embedded in paraplast plus (Oxford Labs, USA) in 59°C. Sections were cut longitudinally at 8-12 μm thick by rotary microtome HM 350 Microm (Heidelberg Germany), stained in Safranin O-Fast Green and permanently mount. Finally, observation work was done on a light microscope Mikroskop CX.20. Microscopic images were captured by Optilab camera using Optilab Viewer 2.2. Anatomical measurements were conducted by measuring epidermis, mesophyll and leaves thickness; stele diameter, cortex and aerenchyma thickness of rhizomes; and stele diameter, cortex, endodermis and aerenchyma thickness of roots used Image Raster 3.0.

Chlorophyll content was obtained by rinsed in 85% acetone solution, which is based on Lichtenthaler (1987), and measuring its absorbance using S-22 UV/Vis spectrophotometer (Boeco, Germany) at λ = 663 nm and λ = 645 nm. Chlorophyll a, chlorophyll b and total chlorophyll content were determined as mg L⁻¹. The data were statistically analyzed using SPSS ver. 22. The significance of differences between variables at p < 0.01 or p < 0.05 was checked with using Independent Samples t-Test.

Results. Morphological comparison of intact individual of *T. hemprichii* between heat treatment and normal group was shown on Figure 1. Normal individual had a brighter color and compact and firm texture, whether in leaf, rhizome and root. The opposite, heat-treated individu had a darker color and fragile texture. Both leaves and roots were easily detached from their rhizome.

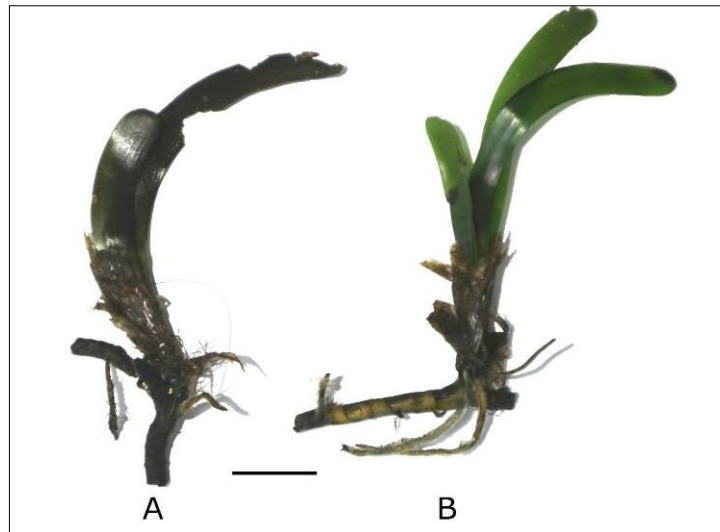


Figure 1. Comparison of the morphology of two intact individuals of *T. hemprichii*. A. Individual of heat-treated group; B. Individual of control group. Bar scale: 2 cm.

Leaves of normal *T. hemprichii* were greenish color while leaves from heat-treated had brownish-green color. It is assumed that *T. hemprichii* leaves were experiencing chlorosis symptom. Leaves damage also shown at heat-treated *T. hemprichii*. Rhizomes of normal *T. hemprichii* were yellowish-green color as well as roots color (Figure 2). Otherwise, the color of rhizomes and roots of heat treatment was brownish black. It seemed that individual from heat treatment underwent decay.

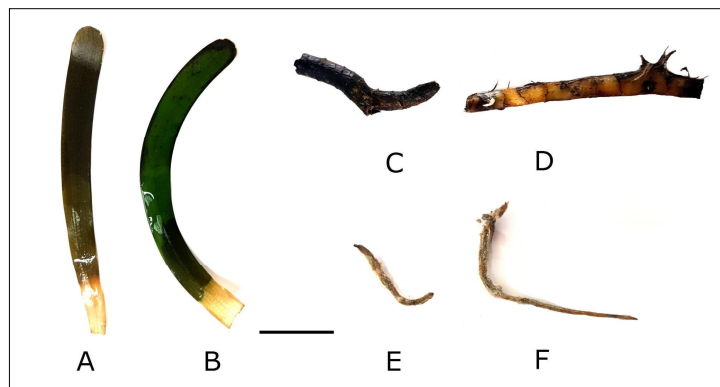


Figure 2. Leaf, rhizome and root morphology of *T. hemprichii*: A-C-E - organs of heat-treated individual; B-D-F - organs of control individual. Bar scale: 2 cm.

Chlorophylls content were measured from the leaf of *T. hemprichii*. These measurements include the content of chlorophyll a, b and total. Generally, the content of chlorophyll a was lower than chlorophyll b. The treated samples had less chlorophyll than the control (Table 1). All parameters were significantly different ($p < 0.01$).

Chlorophyll content of *T. hemprichii* on each treatment

Chlorophyll type	Treatments	
	Heat	Normal
Chlorophyll a	2.93±0.20**	7.01±0.33
Chlorophyll b	2.21±0.15**	4.76±0.32
Total chlorophyll	5.14±0.35**	11.77±0.63

Values represent Mean±SE; ** significant in α : 0.01; n = 10.

Leaf of *T. hemprichii* was isolateral, the abaxial and adaxial sides have the same face. It had cuticle layer outside epidermis and absence of stomata. Epidermis cell in heat-treated leaf had irregular shape (Figure 3A) and its thickness was lower than control leaf (Table 2). In contrast to epidermis thickness, leaf thickness of heat-treated leaf was greater than control leaf. Magnitude of mesophyll thickness seemed to contribute to the thickness of the heat-treated leaf. All parameters of leaf size were significantly different ($p < 0.01$). Stele diameter and aerenchyma thickness of heat-treated rhizome were significantly lower than control rhizome ($p < 0.01$). However, cortex thickness was significantly greater ($p < 0.01$). Microscopic observation of the heat-treated roots showed the presence of various tissue damage (Figure 3E). Stele diameter of heat-treated roots was significantly lower than control root ($p < 0.01$). Whereas, aerenchyma thickness of heat-treated roots was significantly greater in $p < 0.05$ level. Nevertheless, both cortex and endodermis thickness did not show any difference in both groups.

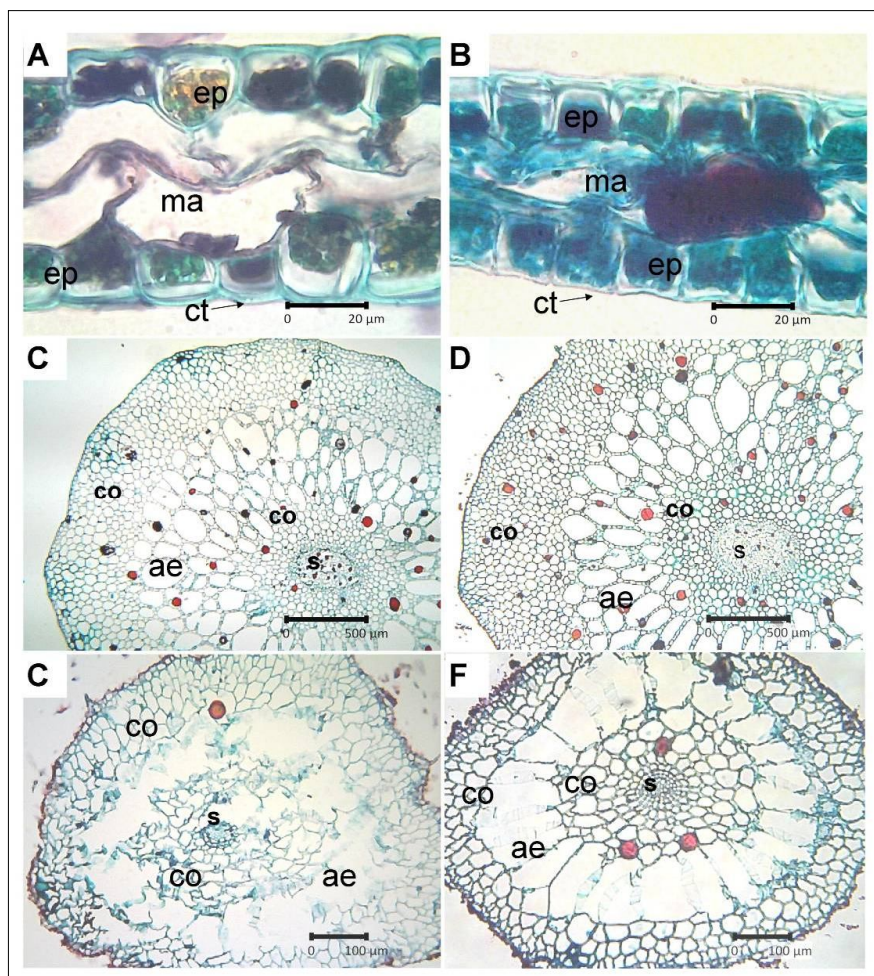


Figure 3. Changes in the anatomical structure of leaves, rhizomes and roots.

A. heat-treated leaf; B. control leaf; C. heat-treated rhizome; D. control rhizome; E. heat-treated root; F. control root; ae. aerenchyma; co. cortex; ct. cuticle; ep. epidermis; ma. mesophyll aerenchymatous; s. stele.

Table 2

Anatomical changes in leaf, rhizome and root of *T. hemprichii* on each treatment

Organ	Tissues	Treatments (μm)	
		Heat	Normal
Leaf	Epidermis thickness	20.39 \pm 0.65**	23.47 \pm 0.41
	Mesophyll thickness	49.71 \pm 1.89**	30.48 \pm 2.08
	Leaf thickness	90.50 \pm 1.20 **	77.43 \pm 1.67
Rhizome	Stele diameter	352.81 \pm 18.00**	434.46 \pm 6.49
	Cortex thickness	851.22 \pm 35.79**	709.09 \pm 35.56
	Aerenchyma thickness	584.86 \pm 24.24**	925.02 \pm 26.91
Root	Stele diameter	63.41 \pm 1.73 **	76.26 \pm 1.88
	Cortex thickness	148.09 \pm 8.97	156.66 \pm 9.50
	Aerenchyma thickness	167.68 \pm 6.79*	148.65 \pm 7.25
	Endodermis thickness	10.29 \pm 0.40	10.80 \pm 0.49

Values represent mean \pm SE; * significant in $p < 0.05$; ** significant in $p < 0.01$; n = 20.

Discussion. Organ damage due to heat stress in *T. Hemprichii* has similar condition to terrestrial plants. Heat stress leads to scorching of organs, senescence, abscission, and inhibits shoot and root growth (Guilioni et al 1997; Ismail & Hall 1999; Vollenweider & Gunthardt-Goerg 2005). Plants exposed to high temperatures above the threshold value (5-10°C above normal temperature) will suffer irreversible damage to their function and development or metabolism cycles, which further lead to a decrease in growth (Porter 2005).

Heat stress on *T. hemprichii* not only caused irreversible damage of any organ and physiology interruption, but also leads to mortality. Leaf chlorosis was closely related to a significant decrease in chlorophyll content due to high temperatures. Siddiqui et al (2015) argued that the decrease in total chlorophyll content is the response of plants due to the heat stress. Declining of chlorophyll content was also reported by Shen et al (2017) in *Rhododendron* sp.

Decrease in chlorophyll content may be caused by the interference with chlorophyll biosynthesis. The interruption of the chlorophyll biosynthesis process occurs due to the inhibition of the electron transport process (Mohanty et al 1989) and inhibition activity of δ -aminolevulinic acid (ALA) synthase, ALA dehydratase, and porphobilinogenase (Tewari & Tripathy 1998). In addition, it was also affected by losing of cell membranes due to accumulation of reactive oxygen species (ROS) resulting in the destruction of thylakoid structures in chloroplasts (Karim et al 1997; Gupta et al 2013). Such effects on chlorophyll or photosynthetic apparatus were suggested to be associated with the ROS production (Camejo et al 2006; Guo et al 2006).

Reaction center of photosystem II (PSII) is highly thermolabile and its activity is briefly decreased even stopped under heat stress (Bukhov et al 1999; Camejo et al 2005). It may be due to the properties of thylakoid membranes where PSII is located. Heat stress may lead to the dissociation of oxygen evolving complex (OEC), resulting in an imbalance between the electron flow from OEC toward the acceptor side of PSII in the direction of PSI reaction center (De Ronde et al 2004). Heat stress causes dissociation of a manganese (Mn)-stabilizing 33-kDa protein at PSII reaction center complex followed by the release of Mn atoms (Yamane et al 1998). Heat stress may also impair other parts of the reaction center, e.g., the D1 and/or the D2 proteins (De Las Rivas & Barber 1997). This study suggested that measurement of chlorophyll content could be a reliable parameter to describe the chloroplast damage and the disturbance of photosynthesis due to high temperature stress.

The decrease in the thickness of the epidermis tissue and the increase in mesophyll tissue thickness and the thickness of the leaf occurring in *T. hemprichii* due to high temperature treatment were also reported in other plants. Similar responses are also reported in *Rhododendron* sp. (Shen et al 2017), *Brassica campestris* (Yuan et al 2017) and *Salvia splendens* (Natarajan & Kuehny 2008). According to Zhang et al

(2005), increased mesophyll thickness due to high temperature was resulted by increased permeability of the plasma membrane.

Anatomical observations of roots and rhizome of *T. hemprichii* were performed by measurement of cortical tissue, aerenchyma tissue and stele tissue. Aerenchyma is developed by aquatic plants along roots, rhizomes to leaves to adapt in conditions of minimal oxygen (Drew et al 2000). The aerenchyma tissue not only provides an internal pathway in oxygen transfer but also reduces the number of oxygen-consuming cells (Canny 1995). Furthermore, Drew et al (2000) also explained that the formation of aerenchyma tissue in the cortical area of root and rhizomes is closely related to programmed cell death (PCD) as a non-tolerant plant response to a stress. High temperatures could denature membrane proteins and increasing unsaturated fatty acids that make cell membranes more fluid (Savchenko et al 2002). Solute leakage occurs as a result of decreased integrity of cell membranes. This condition is commonly used as an indirect indicator of stress on various types of plants (Wahid et al 2007).

Aerenchyma pattern of *T. hemprichii* rhizome was honeycomb schizogeny aerenchyma. However, aerenchyma pattern in root was radial lysigenous. Jung et al (2008) described that those aerenchyma pattern also found in others submerged aquatic plant include family Hydrocharitaceae.

While observation stele tissue aimed to determine the response of vascular tissue due to exposure to high temperature stress. Tupan & Azrianingsih (2016) noted that vascular tissue of *T. hemprichii* was located in stele (central cylinder). During heat stress, in cortical and tracheary elements such as xylem, increased calcium ions and rupture of tonoplasts occur. High temperatures also lead in decreased cell size and an increase in the number of xylem vessels in stem and root of *Lotus creticus* (Bañon et al 2004). In this study, the formation of aerenchyma tissue was the adaptation of *T. hemprichii* as an aquatic plant. While the size change and the presence of damage in various cells and tissues suspected as a result *T. hemprichii* was not able to tolerate the high temperature stress that treated. Therefore, the plant went into death condition (PCD).

Conclusions. High temperature stress affects the morphological and anatomical changes of leaves, rhizomes and roots and decrease of chlorophyll content of *T. hemprichii*. These findings illustrate how *T. hemprichii* response to increase sea temperature due to global warming future. Early mitigation is required for handling and policy making on coastal waters management.

References

- Aswandy I., Azkab M. H., 2000 [Fauna relationship in seagrass beds]. *Oseana* 25(3):19-24. [in Indonesian]
- Bañon S., Fernandez J. A., Franco J. A., Torrecillas A., Alarcón J. J., Sánchez-Blanco M. J., 2004 Effects of water stress and night temperature preconditioning on water relations and morphological and anatomical changes of *Lotus creticus* plants. *Scientia Horticulturae* 101(3):333-342.
- Bergmann N., Winters G., Rauch G., Eizaguirre C., Gu J., Nelle P., Fricke B., Reusch T. B., 2010 Population-specificity of heat stress gene induction in northern and southern eelgrass *Zostera marina* populations under simulated global warming. *Molecular Ecology* 19(14):2870-2883.
- Bitá C. E., Gerats T., 2013 Plant tolerance to high temperature in a changing environment: scientific fundamentals and production of heat stress-tolerant crops. *Frontiers in Plant Science* 4:273.
- Bukhov N. G., Wiese C., Neimanis S., Heber U., 1999 Heat sensitivity of chloroplasts and leaves: leakage of protons from thylakoids and reversible activation of cyclic electron transport. *Photosynthesis Research* 59:81-93.
- Camejo D., Rodriguez P., Morales M. A., Dell'amico J. M., Torrecillas A., Alarcon J. J., 2005 High temperature effects on photosynthetic activity of two tomato cultivars with different heat susceptibility. *Journal of Plant Physiology* 162:281-289.

- Camejo D., Jimenez A., Alarcon J. J., Torres W., Gomez J. M., Sevilla F., 2006 Changes in photosynthetic parameters and antioxidant activities following heat-shock treatment in tomato plants. *Functional Plant Biology* 33:177-187.
- Campbell S. J., McKenzie L. J., Kerville S. P., 2006 Photosynthetic responses of seven tropical seagrasses to elevated seawater temperature. *Journal of Experimental Marine Biology and Ecology* 330:455-468.
- Canny M. J., 1995 Apoplastic water and solute movement: new rules for an old space. *Annual Review of Plant Physiology and Plant Molecular Biology* 46:215-236.
- Chen W. L., Yang W. J., Lo H. F., Yeh D. M., 2014 Physiology, anatomy, and cell membrane thermostability selection of leafy radish (*Raphanus sativus* var. *oleiformis* Pers.) with different tolerance under heat stress. *Scientia Horticulturae* 179:367-375.
- Collier C. J., Waycott M., 2014 Temperature extremes reduce seagrass growth and induce mortality. *Marine Pollution Bulletin* 83(2):483-490.
- De Las Rivas J., Barber J., 1997 Structure and thermal stability of photosystem II reaction centers studied by infrared spectroscopy. *Biochemistry* 36:8897-8903.
- De Ronde J. A., Cress W. A., Kruger G. H., Strasser R. J., Van Staden J., 2004 Photosynthetic response of transgenic soybean plants containing an *Arabidopsis* P5CR gene, during heat and drought stress. *Journal of Plant Physiology* 161:1211-1244.
- Drew M. C., He C. J., Morgan P. W., 2000 Programmed cell death and aerenchyma formation in roots. *Trends in Plant Science* 5(3):123-127.
- Guilloni L., Wery J., Tardieu F., 1997 Heat stress-induced abortion of buds and flowers in pea: is sensitivity linked to organ age or to relations between reproductive organs? *Annals of Botany* 80:159-168.
- Guo Y. P., Zhou H. F., Zhang L. C., 2006 Photosynthetic characteristics and protective mechanisms against photooxidation during high temperature stress in two citrus species. *Scientia Horticulturae* 108:260-267.
- Gupta N. K., Agarwal S., Agarwal V. P., Nathawat N. S., Gupta S., Singh G., 2013 Effect of short-term heat stress on growth, physiology and antioxidative defence system in wheat seedlings. *Acta Physiologiae Plantarum* 35:1837-1842.
- Hemantaranjan A., Bhanu A. N., Singh M. N., Yadav D. K., Patel P. K., Singh R., Katiyar D., 2014 Heat stress responses and thermotolerance. *Advances in Plants and Agriculture Research* 1(3):62-70.
- Ismail A. M., Hall A. E., 1999 Reproductive-stage heat tolerance, leaf membrane thermostability and plant morphology in cowpea. *Crop Science* 39:1762-1768.
- Jung J., Lee C. L., Choi H. K., 2008 Anatomical pattern of aerenchyma in aquatic and wetland plant. *Journal of Plant Biology* 51(6):428-439.
- Karim M. A., Fracheboud Y., Stamp P., 1997 Heat tolerance of maize with reference of some physiological characteristics. *The Annals of Bangladesh Agriculture* 7:27-33.
- Lichtenthaler H. K., 1987 Chlorophylls and carotenoids: pigments of photosynthetic biomembranes. *Methods in Enzymology* 148:350-382.
- Marin-Guirao L., Ruiz J. M., Dattolo E., Garcia-Munoz R., Procaccini G., 2016 Physiological and molecular evidence of differential short-term heat tolerance in Mediterranean seagrasses. *Scientific Reports* 6:28615.
- Massa S., Arnaud-Haond S., Pearson G., Serrão E., 2009 Temperature tolerance and survival of intertidal populations of the seagrass *Zostera noltii* (Hornemann) in southern Europe (Ria Formosa, Portugal). *Hydrobiologia* 619(1):195-201.
- Mohanty N., Vass I., Demeter S., 1989 Impairment of photosystem 2 activity at the level of secondary quinone acceptor in chloroplasts treated with cobalt, nickel and zinc ions. *Physiologia Plantarum* 76:386-390.
- Natarajan S., Kuehny J. F., 2008 Morphological, physiological, and anatomical characteristics associated with heat preconditioning and heat tolerance in *Salvia splendens*. *Journal of the American Society for Horticultural Science* 133(4):527-534

- Nienhuis P. H., Coosen J., Kiswara W., 1989 Community structure and biomass distribution of seagrasses and macrofauna in the Flores Sea, Indonesia. *Netherland Journal of Sea Research* 23(2):197-214.
- Nugraha A. H., Begen D. G., Kawaroe M., 2017 Physiological response of *Thalassia hemprichii* on anthropogenic pressure in Pari Island, Seribu Islands, DKI Jakarta. *Ilmu Kelautan* 22(1):40-48.
- Orth R. J., Carruthers T. J. B., Dennison W. C., Duarte C. M., Fourqurean J. W., Heck K. L., Hughes A. R., Kendrick G. A., Kenworthy W. J., Olyarnik S., Short F. T., Waycott M., Williams S. L., 2006 A global crisis for seagrass ecosystems. *BioScience* 56(12):987-996.
- Pedersen O., Colmer T. D., Borum J., Zavala-Perez A., Kendrick G. A., 2016 Heat stress of two tropical seagrass species during low tide - impact on underwater net photosynthesis, dark respiration and diel in situ internal aeration. *New Phytologist* 210(4):1207-1218.
- Porter J. R., 2005 Rising temperatures are likely to reduce crop yields. *Nature* 436 (7048):174.
- Purnama P. R., Soedarti T., Purnobasuki H., 2015 The effects of lead [Pb(NO₃)₂] on the growth and chlorophyll content of sea grass [*Thalassia hemprichii* (ehrenb.) Aschers.] *ex situ*. *Vegetos* 28(1):9-15.
- Purnobasuki H., Purnama P. R., Kobayashi K., 2017. Morphology of four root types and anatomy of root-root junction in relation gas pathway of *Avicennia marina* (Forsk) Vierh roots. *Vegetos* 30(2):1-5.
- Rasheed M. A., Unsworth R. K. F., 2011 Long-term climate-associated dynamics of a tropical seagrass meadow: implications for the future. *Marine Ecology Progress Series* 422:93-103.
- Savchenko G. E., Klyuchareva E. A., Abrabchik L. M., Serdyuchenko E. V., 2002 Effect of periodic heat shock on the membrane system of etioplasts. *Russian Journal of Plant Physiology* 49:349-359.
- Shen H. F., Zhao B., Xu J. J., Liang W., Huang W. M., Li H. H., 2017 Effects of heat stress on changes in physiology and anatomy in two cultivars of *Rhododendron*. *South African Journal of Botany* 112:338-345.
- Siddiqui M. H., Al-Khaishany M. Y., Al-Qutami M. A., Al-Wahaibi M. H., Grover A., Ali H. M., Al-Wahaibi M. S., 2015 Morphological and physiological characterization of different genotypes of faba bean under heat stress. *Saudi Journal of Biological Sciences* 22(5):656-663.
- Teixeira E. I., Fischer G., van Velthuisen H., Walter C., Ewert F., 2013 Global hot-spots of heat stress on agricultural crops due to climate change. *Agricultural and Forest Meteorology* 170:206-215.
- Tewari A. K., Tripathy B. C., 1998 Temperature-stress-induced impairment of chlorophyll biosynthetic reactions in cucumber and wheat. *Plant Physiology* 117:851-858.
- Tupan C. I., Azrianingsih R., 2016 Accumulation and deposition of lead heavy metal in the tissues of roots, rhizomes and leaves of seagrass *Thalassia hemprichii* (Monocotyledoneae, Hydrocharitaceae). *AAFL Bioflux* 9(3):580-589.
- Vollenweider P., Gunthardt-Goerg M. S., 2005 Diagnosis of abiotic and biotic stress factors using the visible symptoms in foliage. *Environmental Pollution* 137:455-465.
- Wahid A., Gelani S., Ashraf M., Foolad M. R., 2007 Heat tolerance in plants: an overview. *Environmental and Experimental Botany* 61:199-223.
- Waycott M., Duarte C. M., Carruthers T. J. B., Orth R. J., Dennison W. C., Olyarnik S., Calladine A., Fourqurean J. W., Heck Jr. K. L., Hughes A. R., Kendrick G. A., Kenworthy W. J., Short F. T., Williams S. L., 2009 Accelerating loss of seagrasses across the globe threatens coastal ecosystems. *Proceedings of the National Academy of Sciences of the USA* 106(30):12377-12381.
- Yamane Y., Kashino Y., Koike H., Satoh K., 1998 Effects of high temperatures on the photosynthetic systems in spinach: oxygen-evolving activities, fluorescence characteristics and the denaturation process. *Photosynthesis Research* 57:51-59.

- Yuan L., Tang L., Zhu S., Hou J., Chen G., Liu F., Liu S., Wang C., 2017 Influence of heat stress on leaf morphology and nitrogen–carbohydrate metabolisms in two wucai (*Brassica campestris* L.) genotypes. *Acta Societatis Botanicorum Poloniae* 86(2): 3554.
- Zhang J. H., Huang W. D., Liu Y. P., Pan Q. H., 2005 Effects of temperature acclimation pretreatment on the ultrastructure of mesophylls in young grape plants (*Vitis vinifera* L. cv Jingxiu) under cross temperature stresses. *Journal of Integrative Plant Biology* 47: 959-970.

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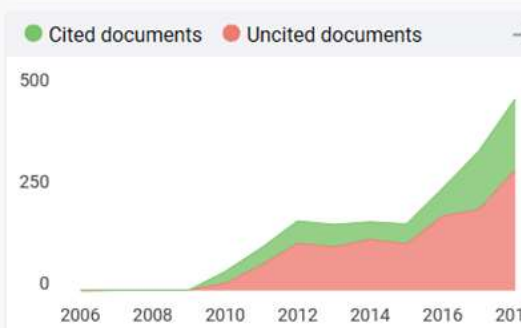
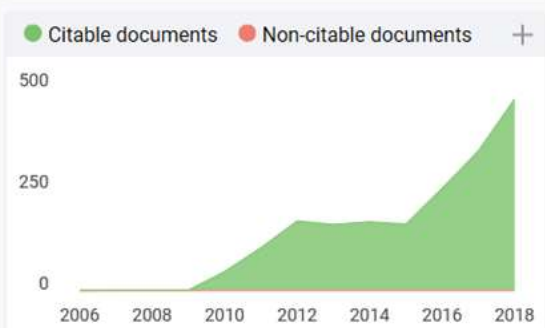
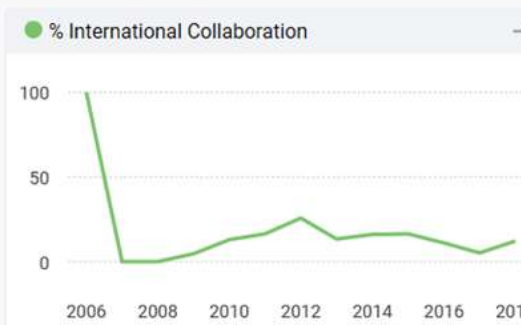
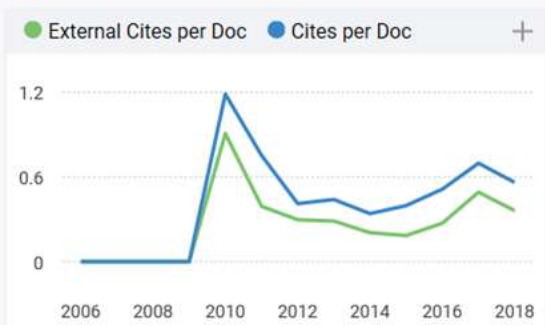
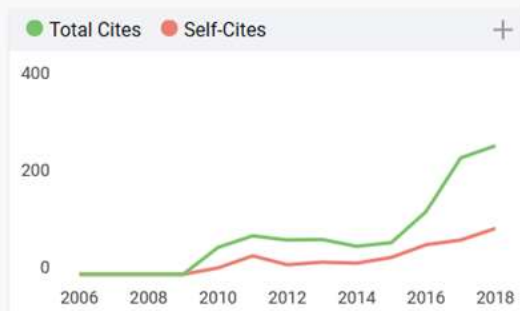
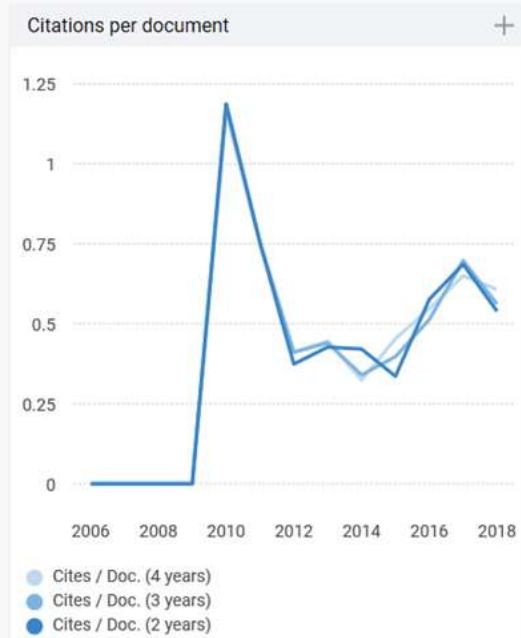
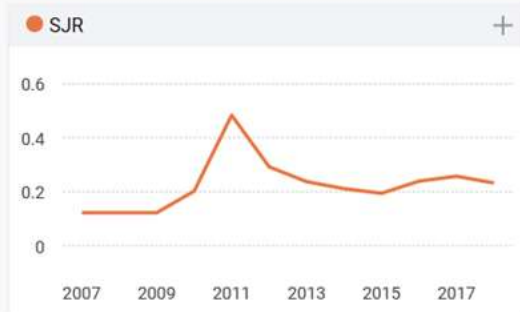
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