UNIVERSITI PUTRA MALAYSIA

SEAWEED EXTRACT FROM Ulva reticulata Forsskal AS ENHANCER FOR SEED GERMINATION, GROWTH AND YIELD OF MONEYMAKER TOMATO VARIETY, Solanum lycopersicum L.

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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June 2020

Chairman : Japar Sidik Bin Bujang, PhD
Faculty : Science

Seaweed *Ulva reticulata* Forsskal was found abundantly and caused a nuisance in seagrass meadow located at Merambong shoal, Sungai Pulai estuary, Johor due to nutrient loading activity from land reclamation and this natural resource, in turn, could be utilized as biofertilizer for sustainable agriculture. This study was conducted to (i) determine the proximate compositions and nutrients content of *U. reticulata* collected from Merambong shoal, Sungai Pulai estuary, Johor; (ii) determine the effects of different concentrations of *U. reticulata* extract on the germination variables of *S. lycopersicum* seeds, Moneymaker variety and; (iii) compare the effectiveness of the *U. reticulata* extracts with other commercial biofertilizer and chemical fertilizer in terms of development and growth, yield, and yield quality of the tomato variety. *Ulva reticulata* samples were collected in January, March, April, and May of the year 2017, from Merambong shoal, Sungai Pulai estuary, Johor, and they were analysed for proximate compositions and nutrients content. *Ulva reticulata* samples in this study contain 85.37% – 88.27% moisture, 13.48 g per 100 g – 22.64 g per 100 g ash, and 20.03 g per 100 g – 22.78 g per 100 g crude protein. The seaweed contains low crude lipid, 0.75 g per 100 g – 0.76 g per 100 g and fiber, 1.65 g per 100 g – 1.93 g per 100 g, which makes them less suitable to be consumed as food. All nutrients showed significant variation and with no specific trend across the months. Total N, Ca, Mg, Cu, Zn, Mn, and Fe were higher in the *U. reticulata* which makes them a potential source of nutrients for crops. These findings revealed that the *U. reticulata* could be used as biofertilizer, and the samples collected in May 2017 was selected to be extracted and further used in this study. The *U. reticulata* samples were processed to produce its aqueous extracts from dried (A) and fresh (B) seaweeds at the concentrations of 5%, 10%, 20%, 30%, 40% and 50%. The extracts were tested to evaluate the germination of tomato seeds, where the concentration of 0% was used as control. There were ten germination variables evaluated, namely, germination percentage (GP), final germination percentage (FGP), mean germination time (MGT), germination index (GI), coefficient of velocity of germination (CVG), germination rate index (GRI), first day of germination (FDG), last day of germination (LDG), time spread of germination (TSG), and seed vigour index (SVI). *Ulva reticulata*

extracts at lower concentrations (5% A, 5% B, and 10% B) enhanced tomato seeds germination, where significantly highest GP (98.3 – 100%), GI (233 – 250), and SVI (41.4 – 49.2), and significantly lowest MGT (4.5 days – 5.4 days), FDG (3 days), LDG (8.3 days – 10.7 days), and TSG (5.3 days – 7.7 days) were recorded. The results also indicated that application of 5% A, 5% B, or 10% B promoted up to 5 days faster to germinate completely as compared to control which took approximately 14 days and significantly higher seed vigourity as compared control as the presence of nutrients in the seaweed extract to enhance germination. Application of higher concentrations of fresh *U. reticulata* extract (> 20% B) inhibited tomato seeds germination due to contained higher in salinity. The effectiveness of the dried and fresh *U. reticulata* extracts at the concentrations of 5%, 10%, 20%, 30%, 40% and 50% were further tested on the tomato variety in the field for a period of 12 weeks (September 2017 to January 2018) in comparisons to commercial biofertilizer (Biofert) and chemical fertilizer (Chemfert) to assess development and growth, yield, and yield quality. Distilled water was used as a control. The treatments were applied weekly (100 mL) by soil drenching and foliar spray to tomato plants. The tomato plant's height was significantly affected by the application of the treatments beginning week 3 to 6 after transplanted and reached a plateau at week 11 after transplanted. Treatment, 50% B, showed superior performance in terms of plant's height, where the height recorded was 15.3 cm on week 3 and reached 49.52 cm on week 6. However, it recorded the lowest yield per plant (23.38 g plant^{-1}) and lowest total yield (140.30 g). The use of other treatments showed fluctuation across the week. Tomato plants applied with Powder, 30% A, 30% B, and 40% B showed the earliest development of flower bud (week 2), early fruiting (week 5), and harvesting (week 10). Application of 40% A showed the highest total yield per plant (106.96 g plant^{-1}), which was 3 times more than control and 2.5 times more than plants treated with chemical fertilizer. Also, treatment 40% A yielded 75.69% of ripening fruits. Generally, the use of dried *U. reticulata* extract resulted in better total and ripen yield as compared to the fresh extracts, and increasing the concentration of the fresh extract >20% reduced the yield. No significant differences in fruit's firmness, total soluble solids, and titratable acidity were found. The ascorbic acid, lycopene, and beta-carotene contents in the tomato fruits were affected by the treatments applied, However, no specific pattern was observed as the concentration of seaweed extracts was increased. The application of 40% A, produced tomato fruits with the highest quality in terms of ascorbic acid (27.88 mg/100 g) and lycopene contents (0.45 mg/100 g), where the lycopene content was 2 times more than Chemfert, and 1.4 times more than Biofert. Different concentrations of seaweed extract resulted on different characteristic of the tomato plant's growth and yield and fruit quality. Therefore, either 5% A or 5% B was recommended to be applied to promote the tomato seeds germination, in addition to the application of 40% A in the field stage to promote better yield and yield quality. Seaweed extract contained abudance of nutrients to promote the growth, development and yield of tomato. The use of *U. reticulata* extract could be a better substitute for the use of chemical fertilizer or other commercial biofertilizers for more sustainable and eco-friendly production of tomatoes.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Sarjana Sains

EKSTRAK RUMPAI LAUT DARIPADA *Ulva reticulata* Forsskal SEBAGAI PEMANGKIN PERCAMBAHAN BENIH, TUMBESARAN DAN HASIL VARIETI TOMATO MONEYMAKER, *Solanum lycopersicum* L.

Oleh

NOR JAWAHIR BINTI ABU

Jun 2020

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Terdapat banyak rumpai laut *Ulva reticulata* Forsskal dan menyebabkan gangguan di kawasan rumput laut yang terletak di beting Merambong, muara Sungai Pulai, Johor disebabkan aktiviti penambahan nutrien dari penambakan tanah dan sumber semula jadi ini boleh digunakan sebagai *biofertilizer* dalam pertanian lestari. Kajian ini dijalankan untuk (i) menentukan komposisi proksimat dan kandungan nutrien pada *U. reticulata* yang dikumpul dari beting Merambong, muara Pulai, Johor; (ii) menentukan kesan kepekatan ekstrak *U. reticulata* yang berbeza pada pembolehubah percambahan biji benih *S. lycopersicum*, varieti Moneymaker dan; (iii) membandingkan keberkesanan ekstrak *U. reticulata* dengan *biofertilizer* komersil lain dan baja kimia dari segi perkembangan dan tumbesaran, hasil, dan kualiti hasil varieti tomato, *S. lycopersicum*. Sampel *U. reticulata* diambil pada bulan Januari, Mac, April dan Mei tahun 2017 dianalisis untuk kandungan komposisi dan kandungan nutrien. Hasil kajian menunjukkan bahawa sampel *U. reticulata* dalam kajian ini mengandungi 85.37 g per 100 g - 88.27 g per 100 g kelembapan, 13.48 g per 100 g - 22.64 g per 100 g abu, dan 20.03 g per 100 g - 22.78 g per 100 g protein mentah. Rumpai laut ini mengandungi rendah lemak mentah (0.75 g per 100 g - 0.76 g per 100 g) dan serat (1.65 g per 100 g - 1.93 g per 100 g) yang menjadikannya kurang sesuai sebagai makanan. Semua nutrien menunjukkan variasi yang siknifikan dan tanpa tren spesifik antara bulan. Jumlah N, Ca, Mg, Cu, Zn, Mn, dan Fe adalah tinggi dalam *U. reticulata* yang menjadikannya sebagai sumber nutrien yang berpotensi untuk tanaman. Penemuan ini mendedahkan bahawa *U. reticulata* boleh dibangunkan sebagai *biofertilizer*, dan sampel yang dikumpul pada Mei 2017 dipilih untuk diekstrak dan seterusnya digunakan dalam kajian ini. Sampel *U. reticulata* diproses untuk menghasilkan ekstrak berair dari rumpai laut kering (A) dan segar (B) pada kepekatan 5%, 10%, 20%, 30%, 40% dan 50%. Ekstrak telah diuji untuk menilai percambahan biji tomato, di mana kepekatan 0% telah dikendalikan sebagai kawalan. Terdapat 10 pembolehubah percambahan yang telah dinilai iaitu peratusan percambahan (GP), peratusan percambahan akhir (FGP), min masa percambahan (MGT), indeks percambahan (GI), koefisien kadar percambahan (CVG), indeks kadar percambahan (GRI) hari pertama percambahan (FDG), hari terakhir

percambahan (LDG), penyebaran penangguhan masa (TSG), dan indeks kekuatan biji benih (SVI). Ekstrak *U. reticulat*a pada kepekatan rendah (5% A, 5% B, dan 10% B) meningkatkan percambahan tomato, di mana GP tertinggi (98.3% - 100%), GI (233-250) dan SVI (41.4 - 49.2), dan MGT yang paling rendah (4.5 hari - 5.4 hari), FDG (3 hari), LDG (8.3 hari - 10.7 hari), dan TSG (5.3 hari - 7.7 hari) direkodkan. Keputusan juga menunjukkan bahawa penggunaan 5% A, 5% B, atau 10% B meningkatkan sehingga 5 hari lebih cepat untuk bercambah sepenuhnya berbanding dengan kawalan yang memerlukan anggaran 14 hari, dan kekuatan biji benih yang lebih tinggi berbanding kawalan kerana kehadiran nutrien dalam ekstrak rumpai laut membantu meningkatkan percambahan. Aplikasi ekstrak *U. reticulata* segar berkepekatan tinggi (> 20% B) menghalang percambahan biji benih tomato disebabkan kemasinan. Keberkesanan ekstrak *U. reticulata* kering dan segar pada kepekatan 5%, 10%, 20%, 30%, 40% dan 50% diuji lebih lanjut pada varieti tomato tersebut di lapangan selama 12 minggu (September 2017 hingga Januari 2018) berbanding dengan *biofertilizer* (Fish Seaweed Extract Organic Liquid Fertilizer) dan baja kimia (Vita-Grow Plus) komersil dari segi perkembangan, tumbesaran, hasil, dan kualiti hasil. Penggunaan 0% ekstrak rumpai laut atau air suling berfungsi sebagai kawalan dalam empat bulan dari September 2017 hingga Januari 2018. Semua rawatan tersebut diberikan secara mingguan (100 mL) dengan menyiram ke atas tanah dan semburan daun kepada tumbuhan tomato. Ketinggian tumbuhan tomato telah terkesan dengan signifikan oleh penggunaan rawatan tersebut bermula minggu 3 hingga 6 selepas dipindahkan, dan mendatar pada minggu 11 selepas dipindahkan. Rawatan 50% B menunjukkan prestasi unggul dari segi ketinggian tumbuhan, yang direkodkan adalah 15.3 cm pada minggu 3 dan mencapai 49.52 cm pada minggu ke 6. Sebaliknya, 50% B memberi kesan negatif kepada hasil tomato kerana ia mencatatkan hasil terendah per tanaman (23.38 g tanaman^{-1}) dan jumlah hasil (140.30 g). Penggunaan rawatan lain menunjukkan fluktuasi merentasi minggu. Tumbuhan tomato yang diberikan serbuk rumpai laut, 30% A, 30% B, dan 40% B menunjukkan perkembangan terawal bunga (minggu 2), buah awalan (minggu 5), dan penuaian (minggu ke-10). Aplikasi 40% A memberikan jumlah hasil per tumbuhan tertinggi (106.96 g tumbuhan^{-1}), iaitu 3 kali ganda lebih tinggi daripada kawalan dan 2.5 kali ganda lebih tinggi daripada tumbuh yang dirawat dengan baja kimia. Di samping itu, rawatan 40% A menghasilkan 75.69% buah masak. Secara amnya, penggunaan ekstrak *U. reticulata* kering menghasilkan jumlah dan hasil buah masak yang lebih baik berbanding dengan ekstrak segar, dan peningkatan kepekatan ekstrak segar >20% memberikan kesan secara negatif kepada hasil. Ketegasan buah tomato, jumlah pepejal larut, dan keasidan didapati tidak terjejas. Kandungan asid askorbik, likopin, dan beta-kerotin dalam buah tomato terkesan oleh rawatan yang digunakan. Walau bagaimanapun, tiada corak spesifik diperhatikan mengikut kepekatan ekstrak rumpai laut yang ditingkatkan. Aplikasi 40% A menghasilkan buah tomato dengan kualiti tertinggi dari segi asid askobik dan kandungan likopin (27.88 mg/100 g). Kandungan likopin adalah 2 kali ganda lebih tinggi daripada Chemfert, dan 1.4 kali lebih daripada Biofert dan kandungan likopin (0.45 mg/100 g), di mana kandungan likopin adalah 2 kali ganda lebih tinggi daripada Chemfert, dan 1.4 kali lebih daripada Biofert. Kepekatan ekstrak rumpai laut yang berbeza menghasilkan ciri yang berbeza dari pertumbuhan dan hasil tanaman tomato dan kualiti buah. Samada 5% A atau 5% B disyor untuk digunabagi menggalakkan percambahan biji benih tomato, manakala penggunaan 40% A disyor untuk menggalakkan hasil dan kualiti hasil yang lebih baik di lapangan. Ekstrak rumpai laut mengandungi banyak nutrien untuk mendorong pertumbuhan, perkembangan dan hasil tomato. Penggunaan ekstrak *U. reticulata* juga boleh menjadi pengganti yang lebih baik kepada penggunaan baja kimia atau *biofertilizer* komersil yang lain untuk pengeluaran tomato yang lebih lestari dan mesra alam.

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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:

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A.M.	Ante meridiem
AAS	Atomic absorption spectrometer
ANOVA	Analysis of variance
AOAC	Association of Official Agricultural Chemists
BERNAS	Padi Beras Nasional Berhad
Biofert	Commercial biofertilizer, Fish seaweed extract organic liquid fertilizer
CABI	Centre for Agriculture and Bioscience International
Chemfert	Commercial chemical fertilizer, Vita-Grow Plus
CRD	completely randomized design
CVG	Coefficient of velocity of germination
Extract A	Seaweed extract from dried *Ulva reticulata*
Extract B	Seaweed extract from fresh *Ulva reticulata*
FAMA	Federal Agricultural Marketing Authority
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FCP	Forest City Project
FDA	Food and Drug Administration
FDG	First day of germination
FELCRA	Federal Land Consolidation and Rehabilitation Authorithy
FGP	Final germination percentage
GI	Germination index
GP	Germination percentage
GRI	Germination rate index

ha	Hectare
IAA	Indole-3-acetic acid
IBA	Indole-3-butyric acid
ICP-AES	Inductively coupled plasma atomic emission spectroscopy
LDG	Last day of germination
MA	Merambong shoal A
MADA	Muda Agricultural and Development Authority
MC	Merambong shoal C
MGT	Mean germination time
MOA	Ministry of Agriculture
N mm^{-1}	Newtons per millimetre
NFE	Nitrogen free extracts
ppm	Parts per million
RDA	Recommended daily allowance
RDF	Recommended dose of fertilizer
SBE	Shrimp brood stock effluent
SL	seedling length
SLE	Seaweed liquid extract
SPSS	Statistical Package for the Social Sciences
SVI	Seed vigour index
TAL	Tanjung Adang Laut shoal
TNG	Total number of germinated seeds
TNP	Total number of plated seeds
TPP	Tanjung Pelepas port
TSG	Time spread of germination

CHAPTER 1

INTRODUCTION

1.1 Background

Marine ecosystems provide us with natural resources. Concerning this, seaweeds are one of the marine living resources which contribute to the major portion of the profit-making application (Selvam and Sivakumar, 2014). Seaweeds are being produced abundantly every year due to the increasing demands of consumers. (Mohy El-Din, 2015). A total number of 221 species of seaweeds comprising 32 chlorophytes, 125 rhodophytes, and 64 Ochrophyta were used globally (Zemke-White and Ohno, 1999). Marine seaweeds are used for human and animal consumptions, and also utilized as a raw material in various industries, e.g., *Kappaphycus alvarezii* and *Ascophyllum nodosum* used in agriculture, including animal feed and fertilizer, 2 species (*Ulva laetevirens* and *Gracilaria verrucosa*) were used in the paper manufacturing in Italy. Several seaweeds, mainly *Macrocystis*, *Laminaria*, and *Fucus*, were utilized in the 'Roe on Kelp' industry in Canada, Alaska, and the north-western United States. Pacific Herring eggs spawn on the kelps, which are collected as a gourmet food item, *Acetabularia major* for the medicine to treat renal problems and as a laxative in Indonesia and Philippines, *Sargassum* for alginate as gelling agents in South-East Asia (Mohy El-Din, 2015; Zemke-White and Ohno, 1999).

On the other hand, Malaysia's economy is significantly driven by the agriculture sector which in 2004, the government of Malaysia declared the agriculture sector to be the third engine of growth (Mekhilef et al., 2011). The government's policy towards agriculture focuses on increasing production, in order to achieve food self-sufficiency and to develop exports efficiently and competitively. For the crops sector, this effectively means expansion of cultivation, resulting in an increased need for and more efficient use of agricultural inputs, particularly mineral fertilizers. The use of organic fertilizers is developing due to increasing demands especially due to environmental concern; more farmers seek biofertilizer in order to produce more products with minimum negative impacts on the environment. Therefore, it is a fundamental need to seek a new alternative to increase agricultural resistance from negative factors and boost crop productivity in order to have a continuous supply for food and the resources for industries (Arioli et al., 2015).

Seaweed extracts are identified to be potentially in enhancing the soil quality and resulted in increasing productivity of crops as the benefits are just similar to organic manure in agriculture practice (Kannan and Rajendran, 2015). *Kappaphycus alvarezii* extracts have benefited agriculture as an effective natural fertilizer or organic biostimulant in vegetables, e.g., *Abelmoschus esculentus* (okra), *Lycopersicon lycopersicum* (tomato), *Phaseolus vulgaris* (common bean), and *Vigna mungo* (mung bean) (Zodape et al., 2008). According to Selvam and Sivakumar (2014), the applications of seaweed extracts from *Ulva reticulata* and *Ascophyllum nodosum* in agriculture practice helps to stimulate the rate of seeds germination of black gram (*Vigna mungo*), enhance the crop yield and

resistance to stress and disease in carrots (*Daucus carota*). Plant growth-promoting substances such as cytokinins, auxins, gibberellins, abscisic acid, ethylene, polyamines, and betaines in the algal extracts were identified in seaweeds (Crouch and Staden, 1992; Stirk et al., 2003; Blunden et al., 2011). The advantage of using seaweed extracts is that they are organics unlike chemical fertilizer and do not jeopardize the environmental health. They are biodegradable and environmentally safe (Selvam and Sivakumar, 2014).

The production of biofertilizers which significantly enhanced the quality of vegetables in crop productivity or propagation of plants is known as one of the best applications of seaweed. Many seaweed species, mainly brown seaweed, e.g., *Sargassum* spp. and *Turbinaria* spp. are utilized as biofertilizers (Hong et al., 2007). Published reports indicated that seaweeds, especially Ochrophyta or brown seaweed contained abundant of macroelements (Calcium, Potassium, Phosphorus), microelements that are necessary for the development and growth of plants e.g., (Iron, Calcium, Zinc, Manganese, Boron, Molybdenum, Copper), vitamins, antibiotics, and amino acids (Sumera and Cajipe, 1981). Maxicrop, *Ascophyllum nodosum*, AgroKelp, *Macrocystis pyrifera*, Kelp, *Ecklonia maxima*, Seasol, *Durvillea potatorum* are examples of plant growth stimulant found in the market (Khan et al., 2009).

1.2 Justification

Malaysia is a tropical country ranging from 8° 30′ to 24° 50′N with a coastline of approximately 3260 km, and the geographic area covering the waters adjacent to six countries (i.e., Indonesia, Malaysia, Papua New Guinea, the Philippines, the Solomon Islands, and Timor-Leste) in Southeast Asia and the Pacific. The tropical environments in the coastal waters of Malaysia serve a favorable environment for the diversity of seaweeds (Hussin and Khoso, 2017). However, the harvesting and utilization of seaweeds are still below the target of the seaweed applications especially as a seaweed fertilizer because mainly seaweed commodities were highlighted for food products as our late Prime Minister was concerned on developing food farming industry such as seaweeds with a large allocation (Eranza et al., 2017).

Sungai Pulai estuary (located at southern Johor, Peninsular Malaysia) has diverse coastal ecosystems and includes Merambong shoal – one of Malaysia's largest seagrass meadow, the largest mangrove forest in Johor (Sungai Pulai Forest Reserve with 9126 ha), and mudflats (Japar Sidik and Muta Harah, 2011). The seagrass meadows are within the Forest City Project (FCP) and adjacent to the Tanjung Pelepas port (TPP). Country Garden Pacificview Sdn. Bhd. has launched FCP. According to Hossain et al. (2018), seagrass meadows experienced large-scale changes, and coastal reclamation activities have affected the seagrass habitat, reduction in coverage, and area loss due to physical damage and excessive sedimentation. In case of disposal of dredged material, suspended sediments may lead to an increased rate of sedimentation and may cause burial of seagrass meadows at the disposal site. However, seaweed species, such as *Ulva reticulata* Forsskal abundantly bloomed due to the reclamation.

The effects of excessive growth of this seaweed such as causes an unfavourable nuisance and causes negative ecological effects including a decline of seagrass beds due to the reduction of light penetration, gas, and nutrient exchange (Hauxwell et al., 2001; McGlathery, 2001). Besides, it harms fish and invertebrates because dissolved oxygen is used at night under thick algal mats and when the macroalgae decompose. The excess nutrient load is supposed to be one of the major factors responsible for the occurrence of "green tides" (Buapet et al., 2008). *Ulva* spp. are common fast-growing opportunistic macroalgae of the littoral zone and are generally known as one of the genera forming green tides. *Ulva* of various species are usually the first colonizers on an open substrate, and their presence is attributed to their tolerance of a wide range of environments and opportunistic life strategies (Ménesguen et al., 2006).

According to Reka et al. (2017), seaweed showed great variation in nutrient content, which are related to several environmental factors due to changes in ecological conditions that can promote or inhibit the biosynthesis of several nutrients. The monthly variations were observed in Merambong shoal due to active land reclamation during sampling. Monthly sampling was conducted in order to assess the variation in nutrient profile of *U. reticulata*.

This study was conducted with the aim of turning the mass seaweed into something beneficial. Therefore, utilizing this natural resource could provide an opportunity to reduce the abundance of *U. reticulata* to promote ecological balance and provide a more sustainable approach for crop production using *U. reticulata* based biofertilizer. Thus, more studies are required to obtain a better understanding of the aspects of the seaweed, *U. reticulata* macro- and microelements, the effect of seaweeds extracts on crop productivity and the effectiveness of the extract compared to the other organic and chemical fertilizers available in the market. This study is a good practice especially among farmers, to substitute the dependency on chemical fertilizer to obtain better germination, growth and crop yield besides it is low-cost fertilizer and eco-friendly.

Currently, the main vegetable production and consumption in the world, and particularly in Asia, is based on a low number of "world" vegetable species such as tomatoes (Böhme, 2016). In Malaysia according to the FAO (FAOSTAT, 2013), the cultivation of tomatoes is low in 1988 ha probably due to inadequate growing conditions (Böhme, 2016). Tomato is the most popular crop in the region, but yield remains low due to the hot climate and soil diseases. In 2012 the local consumption per capital for tomato was 2.7 kg (FAMA, 2014). However, the supply is still insufficient thus allowing high and increasing import of these vegetables annually. The import of tomato in 2013 was valued at RM58.92 million. Therefore, *S. lycopersicum* was selected to be the test crop as this crop was known to be in high demand among consumers, easily assessed as it is fruit types and a short period of cultivation. Research on seaweed extracts is a common study for certain species of seaweeds such as *Ulva lactuca* on *S. lycopersicum* (Hernández-Herrera et al., 2014; Hassan and Ghareib, 2009; Demir et al., 2006). However, there are fewer records of *U. reticulata* extract being used on tomato crops (Patel et al., 2018).

1.3 Objectives

The objectives of this study are to:

i. determine the proximate compositions and nutrients content of *Ulva reticulata* collected from Merambong shoal;

ii. determine the effects of different concentrations of the *Ulva reticulata* extract on the germination variables of Moneymaker tomato variety seeds, *Solanum lycopersicum* and;

iii. compare the effectiveness of the *Ulva reticulata* extracts with other commercial biofertilizers and chemical fertilizer in terms of development and growth, yield, and yield quality of Moneymaker tomato variety, *Solanum lycopersicum*.

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