EFFECT OF GROWTH MEDIUM AND FERTILIZER TYPES ON THE GROWTH AND YIELD OF MICROPROPAGATED GINGER (*Zingiber officinale* Rosc. cv Tambunan)

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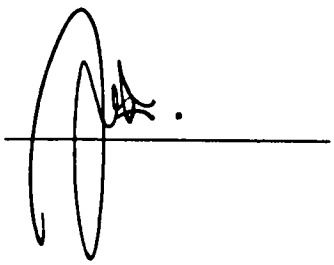

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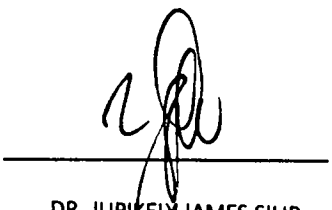

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ABSTRACT

This study was conducted at Faculty of Sustainable Agriculture (FSA), Universiti Malaysia Sabah (UMS), Sandakan, which is located at Mile 10, Jalan Sungai Batang, 90509 Sandakan Malaysia. This study was carried out under rain shelter number 4B to investigate the effect of growth medium and fertilizer types on the growth and yield of micropropagated ginger (*Zingiber officinale* Rosc cv Tambunan). The experimental design was Complete Randomized Design (CRD) using soil as a control treatment for media, Soil: Sand (3:1) and Sand: Cocopeat (1:1). Each medium was treated with pelleted chicken manure and foliar fertilizer. Each of the treatment was replicate 3 times and the observation was done for 24 weeks of planting. Parameters such as plant height (cm), number of leaves and number of tillers were recorded during observations while fresh weight of rhizomes (g), width of rhizomes (cm), length of rhizomes (cm) and dry weight of rhizomes (g) were determined after harvesting. The collected data were analysed using two-way analysis of variance (2-way ANOVA) F-test at 5% level and followed by Tukey Test at the 5% level for the parameters with significant difference through SPSS statistics version 21. Based on the results, there were significant differences between growth medium and fertilizer types for plant height (cm), number of leaves, number of tillers, width of rhizomes (cm) and length of rhizomes (cm) except for fresh weight of rhizomes (g), and dry weight of rhizomes (g). The results indicates that the application of pelleted chicken manure (F1) on the growth and yield of micropropagated ginger was better compared to foliar fertilizer (F2). While growth medium, M1 (Soil) and M2 (Soil: Sand) were found to have better results compared to M3 (Sand: Cocopeat). Therefore, pelleted chicken manure was recommended for ginger planting. Meanwhile, M1 (Soil) and M2 (Soil: Sand) were recommended as planting medium for ginger.

KESAN PERBEZAAN JENIS MEDIA DAN BAJA TERHADAP PERTUMBUHAN DAN HASIL ANAK POKOK HALIA DARIPADA KULTUR TISU (*Zingiber officinale* Rosc. cv Tambunan)

ABSTRAK

Kajian ini telah dijalankan di rumah perlindungan hujan 4B di Fakulti Pertanian Lestari, Universiti Malaysia Sabah (UMS), 90509 Sandakan Sabah. Kajian ini dilakukan untuk mengkaji kesan perbezaan jenis media dan baja terhadap pertumbuhan dan hasil anak pokok halia daripada kultur tisu (*Zingiber officinale* Rosc. cv Tambunan). Dalam kajian ini, tanah akan dijadikan sebagai rawatan kawalan media, Tanah: Pasir (3:1) dah Pasir : Habuk sabut kelapa (1:1). Palet tinja ayam dan baja foliar akan diguna sebagai rawatan bagi setiap jenis media. Setiap rawatan akan mempunyai tiga replikasi dan permerhatian dijalankan pada selama 24 minggu selepas penanaman. Data telah dianalisa berdasarkan kepada beberapa parameter iaitu ketinggian pokok (cm), bilangan daun, bilangan anakan, lebar rizom (cm); panjang rizom (cm); berat basah halia (g) dan berat kering halia (g). Data yang diperolehi dianalisa dengan menggunakan 2 ANOVA dan diikuti ujian Tukey (5%) bagi menguji perbezaan yang ketara melalui perisian statistik SPSS versi 21. Keputusan menunjukkan halia yang ditanam pada media M2F1 (Tanah: Pasir) dan dirawat dengan palet tinja ayam mempunyai min tertinggi bagi ketinggian tumbuhan iaitu (71.57 cm). Manakala berat basah rizom adalah (210.18 g) dan berat kering rizom adalah (17.30 g). Bagi tanah yang dirawat dengan palet tinja ayam menunjukkan (M1F1) kadar min yang tinggi untuk bilangan anak pokok (28.33) dan bilangan daun (228.33). Kelebaran serta kepanjangan rizom adalah tertinggi pada media M2F1 (Tanah: Pasir) yang dirawat dengan baja foliar iaitu masing-masing dengan min (8.40 cm) dan (16.40 cm). Berdasarkan keputusan, aplikasi palet tinja ayam (F1) terhadap pertumbuhan dan hasil halia adalah lebih baik berbanding penggunaan baja foliar (F2). Manakala bagi media pertumbuhan, kajian mendapati media M1 (Tanah) dan M2 (Tanah: Pasir) memberikan kesan yang lebih baik berbanding media M3 (Tanah: Sabut Kelapa). Oleh itu, dapat disimpulkan bahawa aplikasi palet tinja ayam serta media pertumbuhan M1 (Tanah) dan M2 (Tanah: Pasir) adalah sesuai dan efektif bagi penanaman halia.

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%	Percentage
°C	Degree Celsius
µm	Micrometer
ANOVA	Analysis of variance
B	Boron
Ca	Calcium
Ca^{2+}	Calcium ions
cm	Centimeter
CRD	Complete Randomize of Design
Cu	Copper
cv	Cultivar
F	Fertilizer
Fe	Iron
FSA	Faculty of Sustainable Agriculture
g	gram
K	Potassium
K_2O	Potassium oxide
M	Medium
Mg	Magnesium
mm	Millimeter
Mn	Manganese
N	Nitrogen
ns	No significant
P	Phosphorus
P_2O_5	Phosphorus pentoxide
PTM	Primary thickening meristem
R	Replicate
LOI	Loss-on-ignition
kg	Kilogram
mL	Millilitre
L	Litre
Rosc.	Roscoe
S	Sulphur
SPSS	Statistical Package for the Social Sciences
UMS	Universiti Malaysia Sabah
WHO	World Health Organization
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 Introduction

Ginger (*Zingiber officinale* Rosc.) belongs to the family of *Zingiberaceae* and sub-family of Zinigeradeae. Zingiberaceous plant has include 50 genera and 1500 species (Larsen *et al.,* 1999). It is a monocotyledonous crop which also known as a medicinal and spice crop which occurs naturally in various country like India, China, South East Asia, West Indies, Mexico and other parts of the world. Ginger plant is believed to be originated in Southeast Asia. Due to diverse products and the use of ginger, the demand of ginger is increasing every year in the world. Ginger has been proved was cultivated in Malacca region in the year 1416 (Weiss, 2002). Ginger plants are completely sterile as they do not produce seeds and are commonly propagated through its rhizomes (Berg, 1997; Rout *et al.,* 1998). Ginger plant can generally grow up to one to three feet in height. Ginger plants are erect and have many fibrous and fleshy roots, aerial shoots with leaves and the underground rhizomes which is the economic part due to its culinary and medicinal properties. Ginger rhizomes which is pungent and aromatic are usually pale yellow in colour within or with a red external layer (Modupeola *et al.*, 2013). Ginger can be found in markets in different forms such as fresh (green) ginger, preserved ginger and dried ginger where green and fresh ginger are considered as vegetable while dry ginger is considered as spice (Modupeola *et al.*, 2013).

There are at least 172 species including varieties are reported to be found in Indo-Malayan region, the centre of diversity of Zingiberaceae while 80% of them are found in Borneo (Poulsen, 2006). In Malaysia, about 30-40 species of Zingiberaceae have been used as traditional medicines for over 2000 years for treating diabetes, high blood pressure, cancer and other illnesses. Besides food and medicine, ginger has also been cultivated for the use of ornaments (Ibrahim, 1992). Recent studies showed that ginger

varieties are good potential source of anti-cancer, anti-microbial and anti-inflammation (Mohd Habib *et al.,* 2008). Ginger is used as an important drug in the Chinese and Japanese systems of medicines. The dry and fresh gingers are considered two different drugs that used for different purposes (Benskey and Gamble, 1986).

The demand of fresh ginger in Malaysia is higher than the supply, due to the low production. The local demand is expected to increase from 15,575 tonnes in 2005 to 20,000 tonnes by 2010 (Jaafar, 2007). Although the demand of ginger is increasing throughout the years, the area of ginger cultivation keeps deceasing which causes not enough supply of gingers. In the year of 1999, the cultivation area of ginger reduced from 316 hectare to 283 hectare and continued to decrease to 244 hectare in the year 2000 (Firdaus, 2008). In Malaysia, ginger has usually been cultivated in hilly and good drainage areas such as Bentong – Janda Baik, Cameroon Highland and Tambunan. In Sabah, Tambunan is believed have the potential to become the main producer of ginger productions in Malaysia. Shifting cultivation technique is used for ginger cultivation to avoid infertile soil problems and soil-borne diseases caused by *Fusarium oxysporum* and *Pseudomonas solanacearum* which will infect plant roots and also to prevent leaf spot disease (Burrage, 1992; Whipps, 1992). However, this cultivation practice has caused land corrosion mainly in highlands which takes six years to overcome the soil infertility problem before replanting. In order to overcome this issue, organic and inorganic fertilizers are used to increase the fertility of the soils.

Ginger plant requires right kinds and adequate amount of nutrients to sustain their growths and maximum yields especially in the environment with high humidity where rainfall is high and nutrients reserves are low due to leaching and erosion effects. The use of inorganic fertilizers can improve crop yield and soil pH, total nutrient content, nutrient availability but its use is limited due to scarcity, high cost, nutrient imbalance and soil acidity. The use of organic manure has been recommended which can maintain and increase soil fertility (Rodale, 1984; Alasiri and Ogunlele, 1999; Smil, 2000). Animal manure is efficiently used to ensure sustainable crop productivity by immobilizing nutrient that are susceptible to leaching. Application of organic manure is introduced due to its ability to restore soil fertility, supply macro-nutrients such as Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and stabilizer soil pH (Sanchez and Miller, 1986). Besides that, organic manure has the ability to increase soil chemical properties which are essential in crop growth and yield (Adetunji, 1990). Nutrients in the manure are

released more slowly and can be stored in the soil for longer period to ensure longer residual effects, improved root development and higher crop yields (Sharma and Mitta, 1991, Abou Elmagd *et al.,* 2005). Organic fertilizers including manure can increase the availability of nutrients and remedy soil physical conditions.

1.2 Justification of study

Generally, ginger is cultivated by using rhizomes as the planting materials. Mostly, the pre-emergence rot and yellow diseases are transmitted from infected rhizomes (Dohroo, 1989). Ginger rhizomes are used for human consumption and other commercial purposes but a greater portion of yield are needed as planting materials in traditional cultivation of ginger where 50-70% cost of production are spent on planting materials (Villamor, 2010). In order to overcome this problem, *in vitro* culture technology is introduced for rapid propagation of disease free planting materials, overcome seed rhizomes dormancy and to obtain planting materials to cultivate under favourable conditions (Hiremath, 2006). Plantlets produced through tissue culture are then transfer into *ex vitro* conditions. Acclimatization phase need to be done before transplantation from *in vitro* condition to ex vitro condition to increase the vigor of plantlets, resulting in a higher survival rate (Cha-um *et al.,* 2005). Ginger has wider adaptability for different soil types and looser and friable soils will result in higher yields where offer minimum resistance to rhizome development (Kandiannan *et al.,* 1996).

Besides that, large scale use of chemical fertilizers will cause deterioration of soil health in terms of physical, chemical and biological properties. Thus, other source of plant nutrients such as organic manure and vermicompost need to be utilize but they do not supply whole nutrient demands of the crop as a result of very low nutrient availability (Singh, 2015). Since there are less information and studies reported on specific media for this cultivar, therefore this study is conducted to find out the most suitable planting media and fertilizers for this ginger cultivar.

1.3 Objectives

I. To determine the effect of different growth medium on the growth and yield of micropropagated ginger (*Zingiber officinale* Rosc. cv Tambunan)

II. To determine the effect of fertilizer types on the growth and yield of micropropagated ginger (*Zingiber officinale* Rosc. cv Tambunan)

1.4 Hypothesis

I. Ho: Different growth medium do not affect the growth and yield of micropropagated ginger (*Zingiber officinale* Rosc. cv Tambunan)
Ha: Different growth medium do affect the growth and yield of micropropagated ginger (*Zingiber officinale* Rosc. cv Tambunan)

II. Ho: Different fertilizer types do not affect the growth and yield of micropropagated ginger (*Zingiber officinale* Rosc. cv Tambunan)
Ha: Different fertilizer types do affect the growth and yield of micropropagated ginger (*Zingiber officinale* Rosc. cv Tambunan)

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Ginger

Ginger with the scientific name of *Zingiber officinale* Roscoe is one of the most widely used species of the family Zingiberaceae in the order Zingiberales (Zachariah, 2008). Sub-order Scitaminae included 40 genera and hundreds of species. *Zingiber officinale* is slender perennial plant which grown as an annual crop. The leaf stems can grow up to 50 cm tall and with the diameter of 5 mm. The leaf blades are rather in dark green and narrowed evenly to slender tip. The ligule is broad, thin, glabrous and slightly bilobed with slender scape. Ginger plants are erect and have many fibrous and fleshy roots, aerial shoots with leaves and the underground rhizomes which is the economic part for its culinary and medicinal properties. The roots of ginger can be categorized into two types which are fleshy and fibrous. The fibrous roots are thin with root hair and mainly for absorbing water and nutrients while fleshy roots are thicker, milky white in colour with few root hairs and no lateral roots which support the plant and for the purpose of water and absorption too (Ravindran *et al.,* 2005). The flowers are greenish-yellow streaked with purple and they are in little amount and far apart from each other (Zachariah, 2008). Unfortunately, ginger rarely flowers in cultivation (Ghosh *et al.*, 2011).

Ginger is underground stem (rhizome) which used for propagation and storage of food materials. The rhizomes are 7-15 cm long, 1-1.5 cm broad and laterally compressed. The stem contained nodes and internodes where all nodes have axillary buds except for the first few nodes. When the rhizome is planted, only one bud will become active although there may be one or more apical buds on it (Ravindran *et al.,* 2005). If large piece is used, more than a bud will develop simultaneously (Shah and Raju, 1975). Their rhizomes which is pungent and aromatic are pale yellow in colour within or with a red external layer (Modupeola *et al.*, 2013).

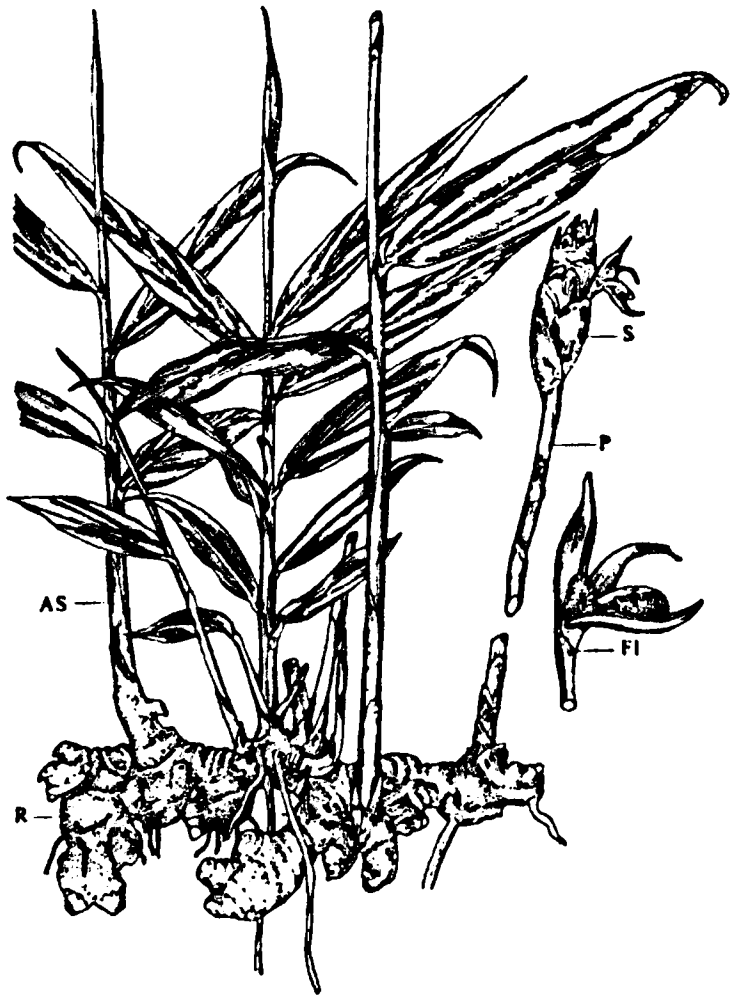

Figure 2.1 and S: Sketch of the ginger plant showing the origin of shoots, inflorescence, flower. AS: Aerial shoot, R: Rhizomes, Fl: Flower, P: Peduncle (Scape), Spike
Source: Ravindran and Nirmal Babu, 2005

2.2 Cultivation of Ginger

Ginger was among the first vegetative cultivated plants (Mahdi *et al.,* 2010). Ginger plant are widely spread around the world, mostly to tropical and subtropical countries from the China-India region. Ginger plant was cultivated India and China since ancient time and is believed to have originated from Southeast Asia. Now, the cultivation of ginger are commonly found in many countries around the world such as India which is the largest producer, followed by China, Jamaica, Taiwan, Indonesia, Thailand, Japan, Hawaii, Sierra Leone, Nigeria, Fiji, Mauritius, Brazil, Costa Rica, Ghana, Bangladesh, Philippines, Sri Lanka, Solomon Islands, Trinidad and Tobago, Uganda, Guatemala and including Malaysia (Ravindran and Nirmal, 2005). Ginger plants has been cultivated for thousands of years for use as a spice and for herbal medicinal purpose (Park and Pizzuto, 2002; Guo and Zhang, 2005; Akram *et al.,* 2011). Weiss (2002) stated that ginger was

cultivated in Malacca region (Malaysia) in the year 1416 by Chinese record. In Malaysia, ginger is cultivated commercially in Bentong, Pahang; Banting, Selangor; Pontian, Johor; Keningau and Tambunan, Sabah and Bakun, Sarawak while Bentong, Bara, China and Indonesia are the main ginger varieties cultivated. Ginger can be harvested after three to four months of planting as young ginger or eight to nine months of planting as mature ginger through commercial propagation method (Suhaimi, 2012).

2.2.1 Cultivation of ginger in field

Tropical or a subtropical climate is required for ginger cultivation. Warm and humid climate are more preferable for ginger cultivation and very important as they are unable to withstand very low temperature. The minimum temperature requirement is 13 °C with an optimum range of 19-28 °C for better growth and crop performance (Hackett and Carolane, 1982). Although ginger can be cultivated in different types of soils such as sandy loams, clay loams, alluvial and lateritic soils but well drained soil, with at least 30 cm depth, loose and friable in texture is more suitable and preferable for ginger cultivation (Prabhakaran, 2013). Compact clay soils and coarse sands with low water holding capacity, gravelly soils or soils with hardpan are unsuitable for ginger cultivation (Lawrence, 1984). The soil hardiness less than 15.7 mm is optimum. Ginger plant prefer more acidic soil with the range of 5-7 which is the optimum pH for ginger plant growth, pH higher than eight will inhibit the growth of the ginger plant.

Ginger cultivation are widely spread and the common methods used for ginger cultivation are ridge and furrow. Based on trails, the most suitable and recommended planting distance is 20 x 20 cm or 25 x 25 cm, raised beds and with a depth of four or five cm with the viable bud facing upwards (Nybe and Raj, 2005). Irrigation technology implemented in ginger cultivation resulted in highest yields when compared to ginger planted in ridges, furrow and flat ground (KAU, 1993). In Malaysia, shifting cultivation technique is introduced in ginger cultivation to avoid infertile soil problems and soil-borne diseases caused by *Fusarium oxysporum* and *Pseudomonas solanacearum* which will infect plant roots and also to avoid leaf spot diseases (Burrage, 1992; Whipps, 1992). Shifting cultivation technique is introduced to prevent the soil-borne and leaf diseases but this technique had caused land corrosion mainly in highlands and takes six years to overcome the soil infertility problems before replanting can be done (Suhaimi *et al.*,

2012). Rhizomes production of ginger in hilly area reduced due to difficult harvesting process along the hilly area (Jaafar *et al.,* 2012).

2.2.2 Cultivation of ginger in green house

Before *in vitro* plants are transferred into soils or fields, cares and maintenances are needed under greenhouse conditions which able to achieve high survival rate of 98% which is comparable to traditionally propagated rhizomes. The morphological characteristics between *in vitro* propagated plants and traditionally propagated clonal seedlings are different. *In vitro* derived ginger plants grew better and produced more rhizomes than plants derived from rhizomes through traditionally propagation method (Ma and Gang, 2006). In open field ginger production, it is very difficult for a grower to prevent any introduction of the diseases from nearby fields which are infected by diseases which will cause by water runoff although disease-free starting materials are used and included the diseases that occurred naturally in the ginger cultivation field (Trujillo, 1964).

2.3 Ginger growth

The vegetative growth of ginger can be classified into three distinct phases. The first phase is from the time of planting to the emergence of shoot which last about 35 - 45 days. It is characterized by root and shoot development as well as root growth. For second phase, it will last for 150 days and comprises of development from the emergence of shoot to flowering. The growth of shoot and leaf take places rapidly while rhizomes growth is relatively slow in this stage. The third stage which is the large stage comprises the period from flowering to harvest of ginger. In this stage, the growth of the leaves and shoots are ceases while the rhizomes grow rapidly (Anderson, 1991).

Dormancy in ginger will occur under 8 and 10 hours of natural photoperiods where 12 and 14 hours of photoperiods are preferable and suitable for ginger cultivation without dormancy which able to achieve highest fresh rhizomes yields. Meanwhile, rhizomes yield for propagation purposes was highest under 10 hours photoperiods and natural photoperiods (Pandey *et al.,* 1996).

2.4 Rhizome Enlargement

There are three meristematic zones involved in the ginger rhizomes enlargement. During the early development stage of rhizomes, a zone of meristematic cell is formed at the base of a young scale leaf primodium. Three meristematic cell will then develop into the primary thickening meristem (PTM) and procambial stands. Meristematic activity if PTM is very important in the enlargement of rhizomes as it involved in the initial increase in the width of the cortex. The second type is actively dividing ground parenchyma and followed by the secondary thickening meristem (STM). In this zone, fusiform and ray initials can be observed clearly. Secondary thickening meristem (STM) develops under the endodermoidal layer.

Primary thickening meristem (PTM) can be identified at a lower level in the rhizomes from the shoot bud apex. The scattered vascular bundles are developing from PTM which can be identified by the plane of cell division. During different growth stages of rhizomes, the separations of procambial cells into vascular tissue occurred with a special meristematic layer along with the endodermoidal layer in ginger rhizomes. This layer comprises of cambium-like cells which are thin-walled and arranged in a biseriate manner. In certain loci, the cells are elongated with tapered ends where the vascular bundles develop and appear to be similar to the fusiform initials with an average of 62.34 μm length and 8.12 μm width in mature stages. Transverse divisions occurred in some cells to form ray initials between these fusiform initials. Inverted and irregularly distributed groups of xylem and phloem are formed along the intermediate layer in cambium-like layer which is an important feature in rhizomes development and filled with starch grains (Ravindran and Nirmal, 2005).

2.5 Hardening stage

Micropropagated plantlets should be gradually acclimatized to the *ex vitro* conditions to prevent high mortality after transfer to the environment of the field due to their physiological and anatomical characteristics (Hazarika, 2003). The special environmental conditions inside the culture vessels with nutrients provided may generate anomalies at both anatomical and functional levels such as hyperhydricity, poor water loss control, low photosynthesis, difficulty rooting and low functionality in plant propagated using *in vitro* techniques (Santana *et al.*, 2011). *Ex vitro* condition has substantially lower relative

humidity, higher light and septic environment contrasted with *in vitro* conditions which causes stress to the micropropagated plantlets.

In vitro plantlets resulting in slower development and a low survival percentage compared to plant cultured by traditional propagation (Marcelo *et al.,* 2015). Under minimum physiological stress, the shoots and plants grown in controlled environment seldom undergo photosynthesis since carbon source is provided. Besides that, the aseptic environment of *in vitro* conditions reduce the stress of pathogens. The rate of water loss from their leaves decreased and photosynthetic ability of the plant increases through the process of acclimatization especially in the leaves newly produced after transfer from *in vitro* condition to *ex vitro* condition resulting in a higher rate of establishment (Nirmal *et al.,* 2005). Gradual acclimatization and hardening are required for most of the plant species for survival and growth in the natural environment (Preece and Sutter, 1991; George, 1996). Ginger plantlets derived from tissue culture developed a functional photosynthetic apparatus and antioxidant enzymatic protective system during acclimation. Newly formed leaves after transplanting are crucial to the plant photosynthesis and growth (Guan *et al.*, 2008).

2.6 *Zingiber officinale* Rosc. cv Tambunan

Sabah is one of the 13 states within the Federation of Malaysia. It is located in the northernmost part of Borneo Island. In Sabah, the native communities commonly use plants that can be found surrounding their houses or in the forest for various purposes in their daily life (Kulip, 2007). 80% of the 172 species (including varieties) in Indo-Malaysia region are found in Borneo (Poulsen, 2006).

Although *Zingiber officinale* Rosc. cv Tambunan is widely cultivated in Tambunan, the ginger production still cannot meet the high ginger demand of 24, 000 kilograms per month in Sabah (The Borneo Post, 2012). In Malay, gingers are loosely called "Halia" and also known as Hayo/ Hazo by Kadazandusun (Kulip, 2007). The geographical area of Tambunan ginger is located in the distinct of Tambunan, Sabah which produces the largest amount of ginger with highest quality. Tambunan ginger has large rhizomes. It is juicy and not too spicy compared to other ginger. Tambunan ginger is grown 750 meters above sea level, where the soil in Tambunan has a pH level between 5.5 and 6.5 while the climate is hot and humid which is suitable for growing ginger (ECAP III, 2010).

Rhizome mixed with a little alcohol is used to massage sprained muscles or for rheumatism and also used to remove wind from body for traditional method.

2.7 *In vitro* propagation of *Zingiber officinale* Rosc. cv Tambunan

The application of tissue culture technique in ginger propagation had been successfully demonstrated in previous studies (Kambaska and Santilate, 2009; Abdelmaged *et al.,* 2011; Mohamed *et al.,* 2011). A large number of planting materials for commercial planting can be propagated by using tissue technique which considered as the best alternative method (Hamirah *et al.,* 2007). Recent study are successfully done in finding the effect of different concentrations and combinations of NAA and BAP on shoot and root multiplications. 3mg/ L BAP + 1mg/L NAA is found to be most effective in shoot multiplication while 2mg/ L of NAA in culture medium is found to be the best treatment in the multiplications of roots (David *et al.,* 2016).

2.8 Medicinal and Pharmacological Properties

Ginger rhizomes has been widely cultivated as a cooking spice and herbal remedy as a treatment in variety of conditions. A considerable enhancement of interest in the use of various types of traditional herbs and plant extracts which included ginger in primary health care and conventional medicine have been witnessed in the past few decades. Ginger is widely used in Indian system of medicine known as Ayurveda and also a very important drug in both the Chinese and Japanese systems of medicine. Both fresh and dry ginger are used in the Ayurvedic system and are used as a common household remedy for various types of illness since ancient (Ramadevi *et al.,* 2005).

2.8.1 Anti-inflammatory effect

The anti-inflammatory properties of ginger have been known for centuries (Afzal *et al.,* 2001; Grzanna *et al.*, 2005). Ginger is used as an anti-inflammatory drug in the Ayurveda, Indian system of medicine (Ghosh, 2011). The World Health Organization (WHO) document (2000) reported that five to 10 percent ginger extract administration brought about full or partial pain relief or recovery of joint function and a decrease of swelling in patients with chronic rheumatic pain and lower-back pain. Ginger contains pungent

phenolic substances, [6]-Gingerol which has antibacterial, anti-inflammatory and antitumour-promoting activities (Zachariah, 2008). Antiangiogenic activity is found in vitro and in vivo (Kim *et al.*, 2005).

2.8.2 Antioxidant effect

Non-volatile fraction of the dichloromethane extract of ginger rhizomes exhibited a strong antioxidative activity using linoleic acid as substrate in ethanol-phosphate in ethanol-phosphate buffer solution (Zachariah, 2008). Besides that, it also functions as a protective layer to toxicity and lethality (Jagetia *et al.*, 2003). The number of tumors, as well as the incidence of cancer was found decreased significantly with the use of ginger as treatment (Manju and Nalini, 2005).

2.8.3 Antimicrobial properties

Ginger extract is found to contain a dose dependent antimicrobial activity against *pseudomonas aeruginosa, Salmonella typhimurium, Escherichia coli* and *Candida albicans* (Jagetia *et al.*, 2003). 10-gingerol was identified as an active inhibitor on these two microbes, *Mycobacterium avium* and *M. tuberculoses* in vitro (Hiserodt *et al.*, 1998). Ficker *et al.* (2003) found that ginger extract had the widest range of anti-fungal activity measured either by the fungi inhibited or as the average diameter of the zones of inhibition although Yin and Cheng (1998) showed that ginger had no effect against some fungi (*Aspergillus niger* and *Aspergillus flavus).*

2.8.4 Cardiovascular effect

Gingerol and shogaol are found in ginger juice which cause vagal stimulation leading to a decrease in both blood pressure and heart rate (Suekawa *et al.*, 1984). Ginger is having stimulatory action on heart muscle which stimulate blood circulation throughout the body (Shoji, 1982). The increased of blood circulation is believed to stimulate cellular metabolic activity which help to relief the cramps and tension (Kobayashi, 1988). Besides that, it also help to reduce the blood pressure and cardiac workload (Tanabe, 1993).

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