FYP FIAT

Effect of compost made with kitchen waste towards the growth of water spinach (*Ipomoea aquatica*)

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A thesis submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (Product Development Technology) with Honours

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DECLARATION

I declare that the work embodied in this report is the result of my research except for individual citations and summaries that I have explained their sources.

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Effect of compost made with kitchen waste towards the growth of water spinach (*Ipomoea aquatica*)

ABSTRACT

Kitchen waste is an excess solid waste production while preparing and processing food from the kitchen as a source of compost ingredient as straightforward as burying food scraps in the ground or utilising a three-stage composting container or tumbler. The composting process will help convert this kitchen waste into a more beneficial organic waste for plant growth. This organic waste will back to the soil as an effective soil amendment with the sustainability of the environment. The objectives of this study were done to study the effect of kitchen waste compost on the growth of water spinach (*Ipomoea aquatica).* This final year project was conducted from October 2021 until December 2021. The treatment of compost using four treatments of compost, namely Treatment 1, T1 (Compost, Control), Treatment 2, T2 (Compost + EM of 10 ml), Treatment 3, T3 (Compost + EM of 20 ml), Treatment 4, T4 (Compost + EM of 40 ml). The soil and compost are mixed as media for planting the water spinach. This project was conducted every day regarding the composting process and plant growth. Plants were grown in the open area, the same environment for all treatment. The results exhibited that T4 (305.40 ± 35.21 mm) is highest in the plant height and the highest length of roots (139.40 ± 12.82 mm). However, the highest length of leaves was exhibited in T2 (61.40 ± 6.07 mm). In addition, state findings and significance proved positively to the study's objective. Composting can drastically reduce the volume of waste in the country as a treatment for organic waste by offering nutrients suited for agriculture and can be used instead of chemical fertilisers. Compost can also be used as soil additions and is environmentally beneficial, hygienic, cost-effective, and toxic-free.

Keywords: composting, kitchen waste, water spinach growth

Kesan kompos yang dibuat dengan sisa dapur terhadap pertumbuhan kangkung (*Ipomoea aquatica*)

ABSTRAK

Sisa dapur ialah pengeluaran sisa pepejal yang berlebihan semasa menyediakan dan memproses makanan dari dapur sebagai sumber bahan kompos semudah menimbus sisa makanan di dalam tanah atau menggunakan bekas atau gelas kompos tiga peringkat. Proses pengkomposan akan membantu menukar sisa dapur ini kepada sisa organik yang lebih bermanfaat untuk pertumbuhan tumbuhan. Sisa organik ini akan kembali ke dalam tanah sebagai pindaan tanah yang berkesan dengan kelestarian alam sekitar. Objektif kajian ini dilakukan untuk mengkaji kesan kompos sisa dapur terhadap pertumbuhan kangkung (*Ipomoea aquatica*). Projek tahun akhir ini telah dijalankan dari Oktober 2021 sehingga Disember 2021. Rawatan kompos menggunakan empat rawatan kompos iaitu Rawatan 1, T1 (Kompos, Kawalan), Rawatan 2, T2 (Kompos + EM sebanyak 10 ml), Rawatan 3, T3 (Kompos + EM sebanyak 20 ml), Rawatan 4, T4 (Kompos + EM sebanyak 40 ml). Tanah dan kompos dicampur sebagai media penanaman kangkung. Projek ini dijalankan setiap hari berkenaan proses pengkomposan dan pertumbuhan tumbuhan. Tumbuhan ditanam di kawasan terbuka, persekitaran yang sama untuk semua rawatan. Keputusan menunjukkan bahawa T4 (305.40 ± 35.21 mm) adalah tertinggi dalam ketinggian tumbuhan dan panjang akar tertinggi (139.40 ± 12.82 mm). Walau bagaimanapun, panjang daun tertinggi ditunjukkan dalam T2 (61.40 ± 6.07 mm). Di samping itu, nyatakan dapatan dan kepentingan untuk ini terbukti dalam hubungan yang positif dengan objektif kajian. Pengkomposan secara drastik boleh mengurangkan jumlah sisa di negara ini sebagai rawatan sisa organik dengan menawarkan nutrien yang sesuai untuk pertanian dan boleh digunakan sebagai ganti baja kimia. Kompos juga boleh digunakan sebagai tambahan tanah dan bermanfaat kepada alam sekitar, bersih, kos efektif dan bebas toksik.

Kata kunci: pengkomposan, sisa dapur, pertumbuhan kangkung

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LIST OF ABBREVIATIONS

No.	Reference	Pages
MSW	Municipal Solid Waste	3
COVID-19	Coronavirus disease	4
C/N	Carbon to nitrogen ratios	9
FAO	Food and Agriculture Organization	11
EM	Effective Microorganisms	13
IMO	Indigenous microorganisms	20
HPPE	High-performance polyethylene	27
T1	Treatment 1	30
T2	Treatment 2	30
T3	Treatment 3	30
T4	Treatment 4	30
CRD	Completely random design	32

CHAPTER 1

INTRODUCTION

1.1. Background of the study

This study is conducted on kitchen waste as a source of compost ingredient as straightforward as burying food scraps in the ground or utilising a three-stage composting container or tumbler. The ultimate product is nutrient-dense soil additives that improve porosity and help the soil retain moisture. Mahmud *et al.* (2019) stated that kitchen waste is an excess solid waste production while preparing and processing food from the kitchen, usually in bulk quantities of the total solid waste. Kitchen waste is also a part of domestic waste. Food waste is undesirable from uncooked and cooked food discarded during or after preparation that does not fit consumption. These leftover substances are usually managed in large quantities, which causes the landfill environment to deteriorate due to gas emissions and the production of a lot of liquid.

Many people have a basic knowledge about the preparation and processing of compost, and sometimes a few individuals get its complexity. However, people who better understand composting can make wise decisions to produce effective and efficient compost. Composting is when organic materials decompose into simpler organic and inorganic compounds in an aerobic process by microorganisms. Composting is a safe procedure for managing waste (Ayilara *et al.*, 2020).

The composting process can take three to six months, but reaching the compost becomes mature takes around three to four months before use. Final compost can be used as a soil conditioner and fertiliser with a high amount of carbon and nitrogen used in agriculture, giving poor people the opportunity to seek income and employment (Mahmud *et al.*, 2019).

Organic matter decomposes by microorganisms under the absence of oxygen is a slow process from composting due to minor heat production. However, composting with oxygen helps the environment by reducing methane gas emissions and toxic leachates released into the atmosphere. Thus, the minimum ecological effect and the final product of compost used to rebuild depleted soils can help by decreasing pollution (Mehta & Sirari, 2018).

Ipomoea aquatica (water spinach) is a semi-aquatic plant grown commercially in South East Asia. Water spinach is easier to obtain in plenty during specific seasons. It grows naturally in water or moist soil with the needed least of care. Water spinach is used extensively in Southeast Asia, such as in China, Hong Kong, Indonesia, Malaysia, and Singapore (Kaur *et al.*, 2016).

Hence, the present study mainly focuses on the effect of kitchen waste composting by showing an impact on the growth of water spinach with the following objectives.

1.2. Problem statement

In Malaysia, households are the primary source of Municipal Solid Waste (MSW). From solid waste collection data, this sector produces around 44.5% of 6.1 million tonnes a year. Up to 20 different classes include food waste, making up half of the total waste composition in MSW (Ismail *et al*., 2020). Management for municipal solid waste still uses an old method only collected, transported, and disposed into landfills. Thus, the waste becomes not a resource because attempts are limited to recycling into beneficial products. Typically, scraps are thrown at an open dumping landfill site (Diaz *et al*.,2020). These conditions lead environmental quality to deteriorate. As an alternative, using composting process will help convert this kitchen waste into a more beneficial organic waste for plant growth (Kamaruddin *et al.*, 2017). Plus, the study shows that this method can produce an effective soil amendment with the sustainability of the environment (Khalib, 2014).

1.3. Objectives

The objective for this project is as follows:

5. To use organic kitchen waste for compost making.
5. To measure the effect of kitchen waste composting
5. To monitor the impact of kitchen waste compost on the growth of water spinach (*Ipomoea Aquatica).*

1.4. Hypothesis

H_0: The different compost treatments made with kitchen waste have not affected water spinach's growth performance.

H_1: The different compost treatments made with kitchen waste have affected water spinach's growth performance.

1.5. Scope and limitation of the study

The research focuses on utilising kitchen waste for compost making while measuring the effect of kitchen waste composting on the growth of water spinach. At first, the composting needs a conducive environment for the microorganism to decompose the dead organic material into the simplest organic matter and inorganic matter. Each composting process requires essential conditions such as the balance ratio of green and brown materials, moisture, heap size, aeration, and particle size for successful composting. The impact of compost making will monitor based on the growth of water spinach.

Unfortunately, several limitations need to be considered and improved since pandemic COVID-19 gives students unable face to face learning at university. Thus, the students need an alternative solution to cope with this situation by doing online learning from home. The composting might take a long duration time until all the organic matter decomposes into mature compost. It depends on the type of materials used, the compost's size, and how it turns; this process can take four weeks to one year until all the organic matter has fully decomposed and is ready to use as a soil conditioner.

1.6. Significance of the study

Organic waste is usually thrown away, but the composting method can reduce pollution to the environment while solving the food waste issue. The compost is preparing to increase soil fertility and crop yield while reducing landfills' burden, and climate change can reduce by sending back carbon into the land. Besides, soil can keep more carbon compared to the atmosphere. However, soils have lost their significant carbon amount because of construction and logging from human activity. For this reason, composting must include an essential practical by analysing the micro and macro effects of methodology for composting. For a home solution, create composting or vermicomposting at the corner of backyards. However, composting from backyards or vermicomposting is a good solution for a small scale. Simultaneously, food waste in huge impact worldwide needs industrial composting that involves large-scale composting with high equipment and technology.

CHAPTER 2

LITERATURE REVIEW

2.1. Composting

Composting is a process of decomposed organic solid waste with adequate moisture and temperature under air (aerobic conditions). The four main components of a composting process are organic matter, moisture, oxygen, and microorganisms. Composting such as manure and other organic waste is enhanced by handling manure methods by decreasing odour or flying. Composting gives potential benefits to land by improving soil fertility and water holding capacity with free foul odours stored in long-term periods. The agricultural operation is suitable for composting because the farm can generate suites quantities and types of waste for the composting process with enough land. Thus, this application of compost to the soil can give benefits with necessary available equipment (Schott et al., 2016; Calabi-Floody et al., 2017).

The maturity product at the final stages of composting affects many factors such as temperature, aeration, moisture content, nutrient availability, and pH. These factors require controlling during their process (Villar et al., 2016).

2.2. The composting process

The composting process has four main components: organic matter, moisture, oxygen, and microorganisms. Epstein (2017) states that organic matter decomposes by microorganisms with oxygen and moisture as the main factor while temperature results from microbial growth and activities in the composting process. However, pH and nutrients are the other essential factor that could constrain the composting process. Carbon and nitrogen play a necessary role in microorganisms to decompose organic matter. Microorganism requires 30 parts of carbon for every aspect of nitrogen they need. If nitrogen is excessive, the microorganisms cannot digest it and produce smelly ammonia gas.

According to van der Wurff, Fuchs, Raviv, and Termorshuizen (2016), bacteria and fungi are essential for carrying out the first stage of the composting process. Bacteria can digest faster organic matter with a high level of simple carbohydrates like sugar compared to fungi. In contrast, fungi are essential for digesting complex carbohydrates like hemicellulose, lignin, and pectin in the next compost stage. The composting process shown in figure 2.2.1 composting has two methods: aerobic composting and anaerobic composting.

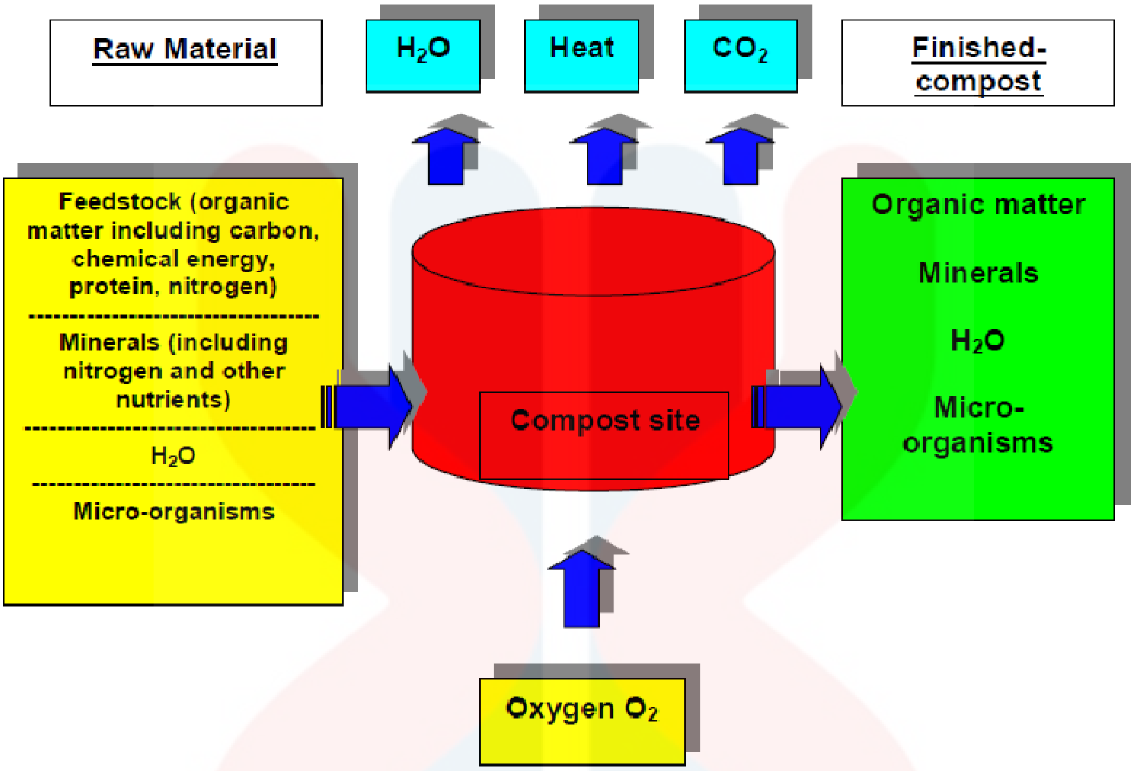


Figure 2.2.1: Composting process. (Source: Epstein, 2017; Kumar, 2011).

2.3. Aerobic composting

Decomposition of organic waste from complex becomes the simpler organic matter using the microbial in the presence of oxygen in aerobic composting. The product in the composting process requires carbon dioxide, ammonia, water, and heat. Practical composting needs the correct ratio from ingredients with suitable conditions. For example, the carbon to nitrogen ratios (C/N) of 30:1 with 60% to 70% of moisture content. A significant carbon source generally comes from straw, wood chips, mixed paper, autumn leaves, etc. while, nitrogen source from vegetable scraps, coffee grounds, manure, food wastes, and grass clippings. It is vital to ensure the composting has a good source of oxygen and ventilation of the waste (Cai et al., 2018).

2.4. Anaerobic composting

Anaerobic composting is the degradation of organic waste using microorganisms from complex becomes the simpler organic matter with the absence of oxygen. This composting lack heat sources; thus, it took a longer duration to compost it. It can cause the growth of pathogens, weeds, and seeds, which release methane gas into the atmosphere. Anaerobic composting use as the traditional method to compost manure from animals and human sewage sludge. However, this method has become more common in treating municipal solid waste and green waste (O'Keefe et al., 1993; Tweib et al., 2011; Komilis et al., 2017).

2.5. Methods of composting

Many composting methods develop over time. The preferred compost method depends on selecting the production scale, quality materials, geographic and climate environment. Thus, labour requirement also the preference of the compost producer. A large number of the existing system are capable of producing a good standard of compost. However, the possibility to make low quality compost can happen with all the present method. Management of the composting process can determine the quality of compost, whether in high or low quality. Management must adapt with the system to follow the size of the compost pile as the example (Fuchs & Cujipers, 2016).

The composting method for small-scale composting consist of traditional methods (anaerobic composting) (Table 2.5.1) and rapid methods (high aerobic temperature composting) (Table 2.5.2). Aerobic decomposition occurs in a natural process without any elements, while the anaerobic decomposition process undergoes without water until three months in the same place. The composting process up to two months during the active composting process up four months above. The rapid composting process involved additional elements like effective microorganisms and worms for practical decomposes of organic matter. This method takes less than a month to produce the compost (SI, 2016).

Table 2.5.1: Traditional composting method

Composting method		Description
Anaerobic decomposition	The Indian Bangalore Method	For extensive scale decomposition. It needs six to eight months for the decomposition to complete. Primarily for urban waste treatment.
	Passive composting of Manure Piles	It involves simple stacking materials in piles to degrade with little agitation and management for a long time. They are usually composting for animal waste. Undergoes anaerobic decomposition with low temperature, slow decay, and hydrogen sulphide releases the foul smell.
Aerobic decomposition (Passive aeration)	The Indian Indore Method	Made by Howard at Indore in India from 1924 to 1926. It uses the pit method and heap method
	Chinese rural composting	It uses the pit method with high-temperature compost.

Source: Food and Agriculture Organization of United Nations (2003)

Table 2.5.2: Rapid composting method

Composting method	Description
Bin composting	Simplest in-vessel method. No turning materials and better temperature control It can eliminate weather problems but have odours.
Rotating drums	To mix uses a horizontal rotary drum with moving and aerating the material through the system. Air supply through the discharged end. The drum can open or partition.
Vermicomposting	For large and small scale uses, red worms. During the process, the worm decomposes all the organic material. It takes at least three to four months to produce compost.
Shredding and frequent turnings	It is usually in a pile for composting The compost pile turns to prevent the pile from getting too hot and being aerated. The material reaches an optimum temperature much time.
Silos	The invessel technique resembles a bot-tom-unloading silo. The aeration system blows air up from the base of the silo through the composting materials.
Aerated Static Pile Composting	The breakdown material helps by the air from the pile through pushing mechanisms. It consumed a small space with less odour production.
Use of Effective Microorganisms (EM.)	It builds in a bin or pile for their compost.

Effective microorganisms have bacteria culture that added into raw material to rapid the composting process.

Source: Food and Agriculture Organization of United Nations (2003)

2.6. Compost parameters

2.6.1. Moisture content

An ideal compost has 40% to 60% of moisture content. If the lower moisture content can cause the composting process to break down, the organic matter becomes slower with limited microbial activity. Compost contains higher moisture content; it produces an unpleasant smell under anaerobic conditions (SI, 2016).

2.6.2. Carbon to nitrogen ratio (C/N ratio)

Proper composting needs an adequate carbon to nitrogen ratio as essential properties. Carbon is an energy source for microorganisms, while nitrogen is a building block for protein. Microorganisms break down organic matter need more carbon sources than nitrogen. An ideal C/N ratio is between 25:1 to 30:1. If the C/N ratio is higher than 40:1, the compost is slower to break down the organic matter because of the growth of microbial activity insufficient amount of nitrogen. However, if the C/N ratio is less than 20, show more nitrogen amount in the compost. Thus, the nitrogen will release the atmosphere as ammonia gas by produce the foul smell of compost. Compost with a low C/N ratio has a large amount of green material, while a higher C/N ratio has more dry cloth in compost (Fuchs & Cuijipers, 2016). The C/N ratio of different organic materials is shown in Table 2.6.2.

Table 2.6.2.: The C/N ratio of different organic materials is essential in designing a good starting mixture.

Organic material	C/N	Organic material	C/N
Urine	0.8	Kitchen organic waste	15-25
Feathers	4-5	Ideal C: N of starting mixture	30-35
Chicken manure	8-10	Garden waste	20-35
Food waste	14-17	Coffee grounds	20-30
Grass clippings	9-25	Fruit waste	25-40
Hay	15-25	Nut shells	35
Mature compost	12-15	Tree leaves	40-70
Young compost	15-18	Straw	50-100
Cow manure	15-20	Wood (sawdust)	200-500

Source: Fuchs & Cuijipers (2016)

2.6.3. Organic matter

The organic materials have a mixture of brown and green organic material. Brown material supplies carbon, while green material supplies nitrogen. A stable compost with 25%

to 65% of organic matter. If the compost has less than 25% of organic matter, show that the soil or sand mixed into the compost. The decomposition can be incomplete if the organic matter is more than 65%. Organic matter is the main element of compost to show improved soil health (Sullivan et al., 2018).

2.7. Basic standard of testing on composting

2.7.1. Visual Screening

According to Sullivan and Miller (2001), visual screening can already provide a preliminary assessment of the compost's quality. The following elements to check; temperature, colour, odour, and plant material non-degraded. Compost that has achieved maturity and stability will have mild temperature based on the surrounding air temperature. Even if the compost appears to be heated, it still produces heat due to the decomposition of organic material.

Furthermore, finished compost looks and smells like rich, dark earth rather than rotting vegetables with a dark brown, crumbly texture. The darkness of a colour compost depends on the moisture content. For example, compost has a black colour showing higher temperature during composting, but vermicompost or compost use other bigger organisms in black colour (Hemidat et al., 2018).

Moreover, mature compost should have an earthy smell. Compost has an ammonia smell of too much nitrogen loss because the feedstock mixture is too low in carbon-nitrogen ratio and has low moisture content. While compost undergoing anaerobic produce sulfur which has rotten eggs smell (Jilani, 2007). Composting process is still in progress or has been paused due to less-than-ideal conditions will have non-degraded plant material or waste such as small branches, grass blades, eggshells.

2.7.2. Moisture content

Sullivan and Miller (2001) state the best moisture content at 40-60% based on the weight. Compost has less than 35% moisture content level can limit microorganisms to decomposed organic matter, leading to compost's rotten smell and undergoes in anaerobic process. At the same time, the compost stored for a longer duration can cause moisture loss and usually in dusty conditions. Unfortunately, compost's high moisture content above 60% is clumpy and hard to spread. In addition, the quick test to determine moisture content using a moisture meter. An accurate result needs to take several times for reading to receive a more comprehensive image in a heap and the pH that can be recorded together (Iqbal et al., 2010).

2.7.3. pH

pH had defined as measures the acidity and alkaline of soil or compost. The pH value starts from 0 to 14, with a seven value of pH regarded as "neutral". A pH of fewer than seven means that the substance is acidic, while a value of above seven that it is alkaline. The starting pH of waste, garden clippings, manure, and other compostable materials is probable between 5.0 and 7.0 if it contains ash or highly alkaline materials. Most organisms thrive at a pH of 6.5 to 7.5, making keeping the pH in that range ideal. But, composting certainly in a batch-process method will make minimum changes in the pH that state is a normal condition (Cao et al. 2019; Sundberg et al. 2004; Boelens et al. 1996).

Most completed composts have a pH range of 6.0 to 8.0. The pH of the finished compost is greatly dependent on the feedstock, the composting process, and any additives added. However, excessive acidity or alkalinity can harm plant roots, preventing them from growing and developing correctly. For example, wood can be highly acidic, whereas lime-treated biosolids can be a significant source of alkalinity (Sullivan & Miller, 2001). According to Kadir et al. (2016), their findings state that the initial composting the pH will drop into acid level because the organic acids are produced until pH rise to 8.6 then decline to 6.3. The process appears due to microbial growth activities that break down the ammonification and mineralisation of organic matter.

2.8. Maturity and stability of compost

Bernal et al. (2017) state that the stability of compost when it passes into maturity test is that product ready to be sold in the market. It is a condition for compost maturity and is evaluated as the decomposition potential of organic matter. Unfortunately, the compost will continue to decompose after soil addition when using unstable compost. The degradation microorganisms will strive for nitrogen with the crop on soil crops planted. Unstable compost that operates as a growing medium for the plant can cause deficiency from oxygen. This process is due to degradation activity from microorganisms that can produce toxic ammonia substances for roots.

Maturity of compost happens when the slow decomposition process by microorganisms due to all organics that have been decay and degradation. Then, the compost maturity characteristics when all organics had decomposed by leaving dark soil colour with earthy smelling material (Villar et al., 2017). This can be supported by Bazrafshan et al. (2016), compost conditions can achieve stability without going maturity process. For instance, compost needs to remove the moisture by drying them due to more accessible transportation. Thus, it can decrease biological activity if the compost lacks oxygen. Once microorganisms in the compost are exposed to moisture and oxygen can activate the process of decomposition again.

Therefore, between the raw waste and finished compost are a series of degradation steps that harm plants. Compost can produce harmful compounds to plants by taking all oxygen used and reducing nitrogen from the soil during an immature phase (Rastogi et al., 2020). In addition, to determine the maturity of composed by test on carbon-nitrogen ratios, germination rates, and oxygen uptake (Latifah et al., 2015).

2.9. Organic additives in composting

As studied by Khalib (2014) show Effective microorganisms (EM) and Indigenous microorganisms (IMO) is an effective organic additive that helps accelerate the process of composting while producing the high-quality final compost. EM contains a mixed culture of beneficial microorganisms such as lactic acid bacteria, yeast, and a smaller number of photosynthetic bacteria. These organic additives occur naturally by cultivated microorganisms in several methods. Indigenous microorganisms (IMO) are clustered microorganisms that include bacteria, cyanobacteria, and fungi as their primary sources. It is an organism that produces nutrients in the soil. The decomposition process becomes rapid because the combined use of EMO and IMO compare when applying organic amendments. Even though these two methods give advantages for microorganisms digests organic matter into simpler during the composting process. However, both additives are different in the process and ingredients because of their properties.

2.10. Effects of additives on the composting process

Barthod, Rumpel, and Dignac (2018) state that microorganisms naturally develop during composting. Directly or indirectly, adding the additives can cause changes in the aeration, temperature, moisture content, nutrient availability, and pH.

Temperature plays a role important as an indicator for microorganisms' activity and retard the growth of pathogens through higher temperature. Thus, the presence of additives can speed up the process of composting. Biological additives such as minerals can boost microbial activity by a more prolonged thermophilic phase than regular composting (Jiang et al., 2015; Morales et al., 2016). The compost stability can complete after two months when amended with biochar. The addition of biochar from mineral and polymer additives such as jaggery, polyethylene glycol and zeolite for composting of manure, food waste and green waste can increase the temperature (Gabhane et al., 2012; Waqas et al., 2017). In addition, compost added with organic additives has a similar temperature profile with the addition of biochar into compost (Nakasaki & Hirai, 2017). Several additives such as bentonite, lime and phosphogypsum show no changes in the temperature profile. Hence, these additives cannot affect microbial biomass (Gabhane et al., 2012).

Composting process needs optimal aeration. Suppose aeration at a higher rate leading to extreme cooling or low temperature will preventing a thermophilic environment, while aeration at a slower pace leading to anaerobic conditions. Thus, static piles use on the composting material with a force of air system is another example method to develop aeration while producing favourable conditions for microorganisms to digest organic matter (Chen et al., 2015; Manu et al., 2017).

Besides, utilising additives in the composting process indicates that the final product makes soil properties differently. Therefore, this process can complete with more studies to develop the relationship between compost properties, parameters of soil, and effect of plant growth with minimising pollution environmental by improving soil condition.

2.11. Effective microorganisms

Effective microorganisms' technology had started its production in the early 1970s by Professor T. Higa of Japan. The procedure began with an experiment involving mixed bacteria found in all ecosystems. Microbes had been removed after numerous failed efforts, and simpler mixes were tested on plants. Finally, in the late 1970s, EM, a mixture mainly containing lactic acid bacteria, photosynthetic bacteria, and yeast, was produced at a pH of 3.5 (Higa, 2003). Based on figure 2.11.1, the main species involved in effective microorganisms.

Main species of Effective Microorganisms (EM)

Lactic acid bacteria
- *Lactobacillus plantarum*
- *Lactobacillus casei*
- *Lactococcus lactis*

Actinomycetes
- *Streptomycetes albus*
- *Streptomycetes griseus*

Photosynthetic bacteria
- *Rhodopseudomonas palustrus*
- *Rhodobacter spaeroides*

Fermenting fungi
- *Aspergillus oryzae*
- *Mucor hiemalis*

Yeasts
- *Saccharomyces cerevisiae*
- *Candida utilis*

Figure 2.11.1: The main species involved in Effective Microorganisms (Source: Diver, 2001; Sekeran et al., 2015).

Charehgani and Mahdi (2021) state that effective microorganisms have mixed microorganisms that can decrease the growth of pathogenic microbes. This can be supported by Sekeran et al. (2005), "EM can kill disease-causing microorganisms like *Fusarium sp.* usually happen in continuos cropping programs". Examples of bacteria that live in EM like lactic acid bacteria, yeast, phototrophic bacteria. Moreover, EM also enhances soil amendment by developing humus to provide nutrients into the healthy soil and nutrients that benefit plants' growth. But it can control the unpleasant smell in composting (Janas, 2009; Badran et al., 2017). Besides, Jusoh et al., 2013 state that EM can minimise foul odour by increasing the rate of organic breakdown material into simpler and producing more compost nutrients.

2.12. Effective microorganisms (EM) in composting kitchen waste

Effective microorganisms method used to speed up the composting process and produce a better compost product by adding efficient bacteria and molasses. The kitchen waste material changed into small size by chopping it with 1% of a solution of EM in molasses. It can transform into mature compost for up to one month half (Faure & Deschamps, 1991; Mupondi et al., 2006). This can be supported by Higa (2003), about 3000 apartment residents using EM to compost their household waste that decrease into 50% of garbage in Pusan, South Korea. At the same time, students in America are introduced and educated to produce compost by using EM to decompose food waste in school. However, Nair and Okamitsu (2010) study no significant difference between the effect of EM in small scale kitchen waste composting, but they studied that EM enhanced earthworms of reproductive rate can produce a suitable environment for composting in all treatment groups.

2.13. Effects of compost on plant growth and nutrient

The composting process can increase the nutrient availability of plants when applied to the soil. Composting with different textures has a different effect on soil and plant growth properties. In recent studies, Duong, Penfold, and Marschner (2012) have researched that compost has a fine texture that generally has a more significant effect on soil and plant growth properties than compost has a coarse-textured.

Furthermore, in observation based on the study by Kranz et al. (2020), the addition of organic matter can enhance the increase of plant-available water during the relationship in plant water availability with bulk density. The Scoop and Dump method supports the statement that improves the soil on Cornell University's campus by mixing compost at a rate of 15 cm containing 122 cm into the soil profile. The Scoop and Dump soils show higher significant plant-available water on average 0.22 $m^3\ m^{-3}$ compared to the unamended soils with plant water available of 0.15 $m^3\ m^{-3}$(Sax et al., 2017).

Sharma et al. (2017) state plant growth, root development, and nutrient uptake from soil can stimulate the benefit of composting. These studies have found a similar result whereas compost contains beneficial microorganisms that can develop more effective on their root growth with the help of nutrients uptake as eloquently quoted by Ewetola et al. (2019), "Combination of loamy sand with 5 tons per ha of compost is suitable for the early growth of *Moringa oleifera,"*

To conclude, the addition of compost can increase the availability of soil nutrients, and thus plants uptake the nutrient is adding from compost. There are two effects directly and indirectly. Directly effect when nutrients are added through compost while indirect effects increase the microbial activity with better soil structure and water retention. When soil structure and water retention improve conditions that lead to root growth, the plant can access the soil volume. Hence, composts can help plants develop and improve soil chemical, physical, and biological qualities, but immature composting can harm plants and the environment (Fernández-Hernández et al., 2014).

2.14. Water spinach

According to Austin (2007), water spinach *(Ipomoea aquatica*) was once indigenous to Africa, Asia, and the western Pacific Islands. Since at least AD 300, and maybe since 200 BC, the herbs have been used as a medical vegetable in southern Asia. Water spinach had first farmed in south-eastern Asia, according to some reports. The plants may have to cultivate in China.

Furthermore, water spinach is a tropical or subtropical perennial herbaceous aquatic or semi-aquatic plant. It has flat leaves ranging from heart-shaped to long, narrow, and arrow-shaped depending on genotype. Narrow leaves are 20-30 cm long and 1-2.5 cm broad. The massive, gorgeous flowers feature the convolvulus's distinctive open, trumpet shape or bindweed flowers. There are two types of water spinach: green stem (Ching Quat) and white stem (Pak Quat). Green stem is usually grown in beds that provide a lot of moist soil. It has narrow with pointed leaves and white flowers. At the same time, the white stem has grown in aquatic environments. It has broad with arrow-shaped leaves and pink flowers. It is also known as Water Ipomea (Göthberg et al., 2002; Pandey et al., 2019).

Besides, it is locally known as *Karmatha bhaji*. It has a short growing season and may grow on marshy and wet soils. Furthermore, it revealed that water spinach has a significant potential for converting nitrogen from biodigester effluent into high-protein edible biomass (Sophea and Preston, 2001).

Figure 2.14.1: Fresh cuttings water spinach in the local market (Source: Austin, 2007).

2.15. Measurement of plant growth

All plant growth needs media as parameters growth in fresh and dry shoots and roots, shoot and root length, and leaves. According to Marutani and Clemente (2021), their study about the effects of compost media on leafy lettuce *(Lactuca sativa L.*) using pot culture. They analyse the interactions effects of growing media and cultivar type on parameters growth on the dry and fresh weight of plant shoot and root with their length and leaves numbers. However, the effect of cultivar all the parameters not including fresh root weight. Besides, geranium (*Pelargonium zonale L.*) and calendula (*Calendula officinalis L.*) plants had grown on media green waste compost and green waste vermicompost in pots. The plants were analysed based on the number of buds and flowers, plant height, crown width and diameter of the stem, height of roots and shoots. For analysed the weight of roots and shoots is removing plants from the pots then cutting the plants at the medium surface. The shoots and roots were dried in a forced-air oven at 75 ^{o}C until constant weight by getting the actual weight (Gong et al., 2018). Furthermore, the quinoa plant is another example of a growth parameters plant planted using organic amendments from biochar and compost as media. Their parameters growth analyse the root, shoot dry weight and seeds yields. The application mixture from biochar and compost significantly improved plant growth in stressed soils (Ramzani et al., 2017).

CHAPTER 3

METHODOLOGY

3.1 Material and apparatus

The materials which used in this research are garbage bag (74 cm x 90 cm), disposal plastic gloves, empty recycled plastic bottle (1.5 L and 0.6 L), polybag high-performance polyethylene (HPPE) (5 cm x 8 cm), fine coco peat (500 g), water spinach seeds (10 g), airtight container (4.5 L), electronic balance, shovel, spades, plastic ruler (30 cm), multipurpose basket (30 cm x 21 cm x 8.5 cm), A4 papers (70 gsm), EM-1 Microbial Inoculant (1 L), Molasses (1 L), eggshells, tea bag, dry leaves with small branches, newspaper, fruits and vegetable scraps, non-chlorinated water, organic soils and 3-way soil meter. There is not used any laboratory apparatus due to home-based research.

3.2 Methods

3.2.1. Carbon to nitrogen ratio (C/N) of the compost material

The materials used in composting are green material (nitrogen) and brown materials (carbon). The green materials are rich in nitrogen due to managing heat a compost for the faster growth of microorganisms. Then, the brown materials are carbon as food sources other organisms in soil that collaborate with microorganisms to decompose the organic materials in the compost. The brown material used is dried leaves with small branches, cardboard, newspaper. The green material used is kitchen waste, including fruit and vegetable scraps, eggshells, and teabag. Table 3.3 show the C/N of all the material that used in composting.

Table 3.3: The C/N of the materials used in composting.

Materials	C/N Ratio
Food scrap	15:1
Fruits and vegetable trimmings	12:1
Dried leaves	60:1
Newspaper, shredded	170:1
Cardboard	563:1

Sources: Hanson-Harding (2013)

3.2.2. Preparation of Compost sample with Effective Microorganisms (EM)

At first, a bin composter is built by drilling holes four to six inches apart on all the sides of the bin and several holes in the bin's base. The holes allow air movement and the drainage of excess moisture. Often obtain the compost ingredients source from Kuala Lumpur households. The supplied material for kitchen waste composting includes kitchen waste from fruits and vegetable scraps, eggshells, dry leaves with small branches, cardboard and newspaper. All the large ingredients are chopped or shredded up into smaller pieces. Then, add the ingredients rich in carbon (brown materials) and nitrogen (green materials) in alternate layers. The compost ratio is roughly three parts carbon (brown materials) to one part nitrogen (green material). This research used commercial EM-1. According to Lananan et al. (2014), state EM contains lactic acid bacteria, yeast and phototrophic bacteria. The EM solution needs to suspend in a mixture of molasses and non-chlorinated water, which provides nutrients and minerals for the growth of microorganisms.

For compost with inoculation with EM of a 40 ml, 20 ml, 10 ml solution had applied to 20 ml of the amount of water and molasse to add to a given mixture for the compost sample. The activation of EM following after seven days ferment then applied to the compost (treatment EM). Next, water is added to keep the compost moist but not too wet and maintained at 50% to 60% in each composting. The materials break down; thus, the compost will get warm. The compost is stirred at least once a week to eliminate the odour by helping decomposition. All the materials will turn dark with no remnants of food or waste left to show the compost is ready to use. The compost is added to the soil for the growth of the water spinach plant.

3.3 Experimental design

A completely randomised design experiment had started using four treatments of compost, namely Treatment 1, T1 (Compost, Control), Treatment 2, T2 (Compost + EM of 10 ml), Treatment 3, T3 (Compost + EM of 20 ml), Treatment 4, T4 (Compost + EM of 40 ml). In this research, T1 is a control method where no effective microorganisms (EM) are added to the compost. It was possibly not situated at the same place as other compost. The other treatment compost with EM only consisted of T2, T3, and T4. It ensures that the T1 does not expose to EM solution for material degradation. Each treatment's initial and final pH was measured using a 3-way soil meter. Compost degradation was conducted from October 2021 until November 2021 at Kuala Lumpur and continued to Universiti Malaysia Kelantan

Table 3.4: The materials that added in the treatment of compost.

Treatment (sample)	Kitchen waste	Soil	EM-1 + Molasse	Cardboard	Newspaper	Non-chlorinated water	Dry leaves and small branches
T1	+	+	-	-	+	+	+
T2	+	+	+	+	+	-	+
T3	+	+	+	+	+	-	+
T4	+	+	+	+	+	-	+

“+” materials are added in treatment (sample), and “-“ materials are not added in treatment (sample).

3.4 Planting and management

Before sowing, water spinach seeds had soaked in water for 24 hours to encourage germination faster. Then, water spinach seeds have filled in 3/4 each polybag per treatment with the triplicate, 12 polybags arranged using CRD. The plants' watering was done twice a day at 8:00 AM and 5:00 PM until the water was out from the bottom of the polybag. Seedlings were thinned to 5 to 10 plants per polybag 20 days after planting. For pest control, use hand weeding and handpicking of insects.

3.5 Preparation of topsoil and media for planting

This experiment used the ratio 2:1:1 for soil, compost, and fine coco peat for planting the water spinach. Blackish to brown soil and compost is mixed as ground media while using fine coco peat as topsoil due to the higher germination rate of seeds. The soil was collected at Universiti Malaysia Kelantan (UMK) while fine coco peat was bought at the store.

3.6 Data collection and analysis

Water spinach plants were harvested 35 days after planting. Plant height, root length, and leaves length had measured. All parameters measurement had recorded and expressed in (mm). All experiments had repeated in three replicates with four treatments. The means of the parameter had compared by Tukey HSD post hoc using SPSS software (SPSS for Windows) and statistically assayed by Analysis of Variance (ANOVA).

CHAPTER 4

RESULT AND DISCUSSION

4.1. Treatment of compost

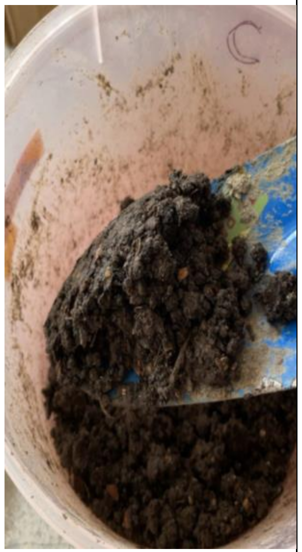
In this research, the initial pH for treatment of compost shows ranges between 5 to 6. In comparison, the final pH for all treatment of compost overall shows in 8 except for T4 in 7.5. Measurement of pH using a 3-way soil meter that has been measured. According to Sundberg et al. (2013), compost's pH is between 6 and 8, about neutral. However, because home compost usually with a mix of vegetable trimmings, food waste, and other household biodegradable materials, the initial pH is likely to be more acidic, ranging between 5.0 and 7.0. If a significant component of the composted material contains wood shavings or peat moss, such as from chicken bedding, the pH can drop to as low as pH 4.5.

Besides, the observation of compost for the final product shows all materials decomposed except the eggshells and a few delicate branches. At the same time, the texture is crumbly and smooth with an earthy smell that shows once from characteristics of maturity compost. Another reason is compost treatment is under the aerobic condition where microorganisms decompose the materials that require oxygen. If the compost has traces of ammonia or has a foul odour, it requires additional time to mature (Jilani, 2007).

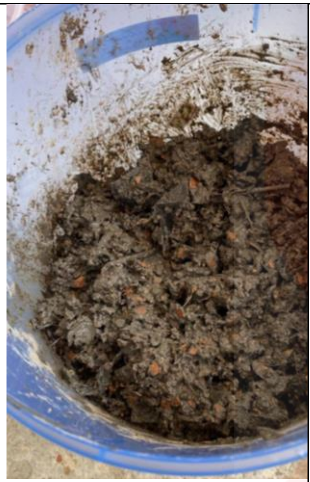
Sekeran et al. (2005) mentioned that the measurement ratio of carbon and nitrogen indicated the degree of decomposition. Before composting, waste of the carbon and nitrogen ratio was higher than after composting. The presence of EM can increase the breakdown of organic matter by lowering the carbon and nitrogen ratio. A low C: N ratio speed up the decay rate but may cause a loss of nitrogen as ammonia gas and rapid depletion of the available oxygen supply, leading to horrible smell conditions. Although EM controls the horrible smell and the process is free of odours. Anaerobic bacteria take over when oxygen is absent. Composting in a trench, sack, or garbage can might result in an anaerobic process that the final product is highly acidic. The pH of anaerobic compost is too high for most plants. Thus it should be exposed to air for a month or until the pH is neutralised.

The use of EM in organic matter composting produced positive results in terms of breakdown and mineralisation. When compared to compost without EM, the results reveal that EM compost has a faster decomposition rate, is richer in nutrients, has more microbial activity, has better germination, and has higher yields (SI & S, 2016; Saravanan et al., 2013; Mbouobda et al., 2014). Furthermore, by creating enzymes that act on organic wastes and enrich the nutrients in the composting process, EM improved the compost (Saravanan et al., 2013; Mbouobda et al., 2014). According to Daly & Arnst (2005), there was a significant difference between compost treatments with and without EM. The EM treated compost fully composted compared to the non-EM treated compost.

Table 4.1.1: The result of visual screening compost treatment.

Time (Week) / Treatment	1	2	3	4	5	Initial pH	Final pH
T1						5.5	8.0

T2						6.0	8.0
T3						5.5	8.0

							
T4						6.0	7.5

4.2. Length of water spinach roots

In this research, the growth effects length of water spinach roots is the primary plant growth role, showing differentiation between the compost treatment. Therefore, there are statistical differences in the mean length of water spinach roots between the treatment of compost ($P < 0.05$) based on the results in Table 4.2.1. While the result of Table 4.2.2 and Figure 4.2.1 revealed that the highest length of roots was exhibited in T4 (139.40 ± 12.82 mm). T1 accumulated the least amount in length of roots with 87.60 ± 21.58 mm. However, the T3 (114.20 ± 9.68 mm) and T2 (113.60 ± 33.42 mm) results are nearly similar. In addition, Table 4.2.2 below shows a statistically significant difference using Tukey HSD post hoc analysis in mean length of water spinach roots between the compost treatment that took the T1 and T4 treatments. However, there are no differences between the treatment of T2 and T3.

According to van der Wurff et al. (2016), by balancing soil density, compost aids plant growth. Compost helps to loosen soils that are too tight, whereas compost that is too loose tends to clump the soil together. This balancing allows plants to build stronger roots in the soil, which leads to better growth. Furthermore, the uppermost layer of topsoil is where plants root and where most chemical and biological activity occurs. Because it contains most soil organic matter, the upper layer is usually darker in colour. One or more lighter-coloured soil layers lie beneath the topsoil. These layers (compost mixed with soils) are crucial for plant growth, and roots may locate water and nutrients in these deeper layers, limiting nutrient leakage from the subsoil (van der Wurff et al., 2016; Bokhorst & Ter Berg, 2001).

Table 4.2.1: The mean length of water spinach roots between the treatment using one-way analysis of variance (ANOVA).

ANOVA Length of roots					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	6709.800	3	2236.600	4.861	**0.014**
Within Groups	7362.400	16	460.150		
Total	14072.200	19			

Table 4.2.2: The mean length of water spinach roots between the treatment using Tukey HSD post hoc analysis.

Treatments	**Length of water spinach roots (mm) (Mean ± SD.)**
T1	87.60 ± 21.58[a]
T2	113.60 ± 33.42[ab]
T3	114.20 ± 9.68[ab]
T4	139.40 ± 12.82[b]

[a-b] Means within the column with a different letter(s) indicate a significant difference between treatments by Tukey test at $P \leq 0.05$ (Refer table in appendix D). Each value is expressed as the mean ± standard deviation (n = 5).

Figure 4.2.1 below shows the mean root plant, which illustrates the differential between every treatment. In the bar chart graph, a label connects to the means for groups in homogenous subsets displayed by using one-way ANOVA and Tukey HSD post hoc analysis, a and b refer to the subset for alpha = 0.05.

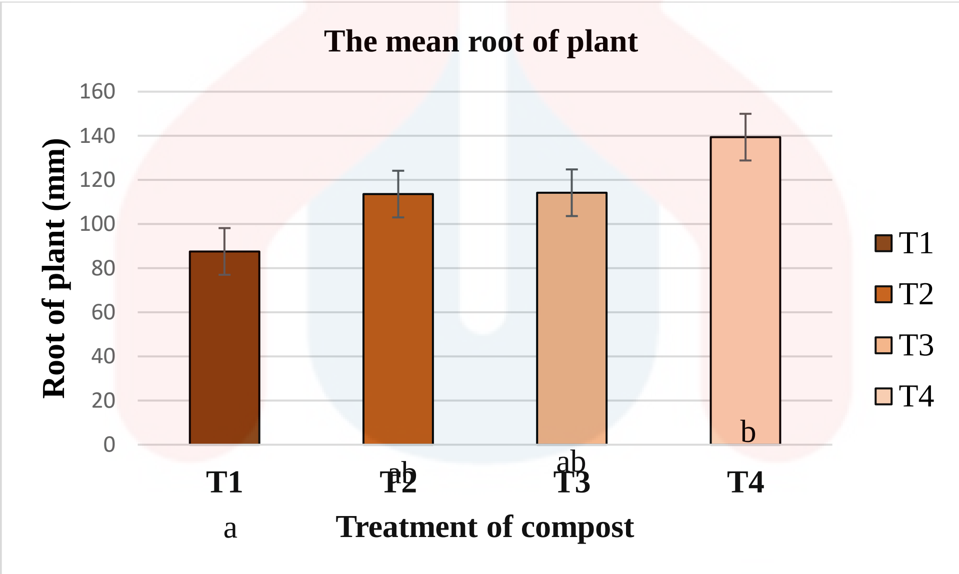


Figure 4.2.1: Bar chart of the mean root of the plant with the treatment of compost.

4.3. Height of water spinach

In this research, plant height plays a significant role in differentiating between primary plant growth and compost treatment. The growing media did affect the height of the water spinach plant ($P < 0.05$). The compost treatment was strongly aerated and supplied more porous segments, which is inappropriate for long-term plant growth despite being essential for seed germination. The water retention potential of medium compactness could be influenced by optimal macroporosity, enhancing plant growth performance (Ruggieri et al., 2009; Drewry et al., 2008).

Therefore, there are statistical differences in the mean height of water spinach between the treatment of compost ($P < 0.05$) based on the results in Table 4.3.1. While the result of Table 4.3.2 and Figure 4.2.1 revealed that the highest plant height was exhibited in T4 (305.40 ± 35.21 mm). T1 accumulated the least amount in plant height with 231.20 ± 18.39 mm. T2 (253.40 ± 13.65 mm) and T3 (292.40 ± 13.72 mm) for another treatment. In addition, Table 4.3.2 below shows a statistically significant difference using Tukey HSD post hoc analysis in the mean height of the water spinach plants between the compost treatment that took the T1 and T4 treatments. However, there are no differences between the treatment of T2 and T3.

The results of this study agreed with bin Shuhaimi et al. (2019) that soil mixed with food waste media as compost produced higher yields of the plant, which significant difference ($P < 0.05$) in their treatments. In addition, these results are the same as a result reported by Grigatti et al. (2007), which effects of compost on plant growth near to species and amount of compost as media that show significantly in the height of plant which ($P < 0.001$). The plant's response to compost treatment depends on the species, source, and amount of compost used.

However, the research focused on the beneficial effects of plant growth that used compost in moderate quantity, about 30% in the mixtures.

Hence, it can be explained that plants that use treatment compost added a higher amount of effective microorganisms had significantly higher growth in height than plants that use compost without adding effective microorganisms. EM providing additional nutrition and enhancing microbial activity for compost in the future give this nutrition for the growth of the plants (Verma et al., 2015).

Table 4.3.1: The mean height of water spinach plants between the treatment using one-way analysis of variance (ANOVA).

ANOVA

Height of plants

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	17672.400	3	5890.800	12.068	**<0.001**
Within Groups	7810.400	16	488.150		
Total	25482.800	19			

Table 4.3.2: The mean height of water spinach plants between the treatment using Tukey HSD post hoc analysis.

Treatments	**Height of water spinach (mm) (Mean ± SD.)**
T1	231.20 ± 18.39[a]
T2	253.40 ± 13.65[ab]
T3	292.40 ± 13.72[bc]
T4	305.40 ± 35.21[c]

[a-c] Means within the column with a different letter(s) indicate a significant difference between treatments by Tukey test at P≤0.05 (Refer table in appendix E). Each value is expressed as the mean ± standard deviation (n = 5).

Figure 4.3.1 below shows the mean plant height, which illustrates the differential between every treatment. In the bar chart graph, a label connects to the means for groups in homogenous subsets displayed using one-way ANOVA and Tukey HSD post hoc analysis; a, b and c refer to the subset for alpha = 0.05.

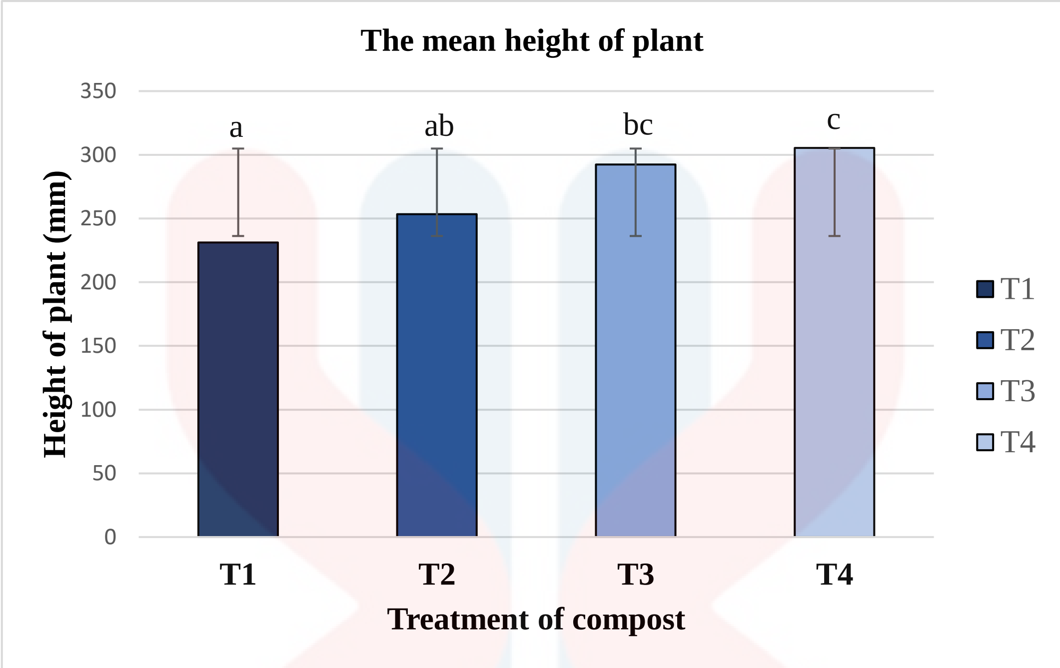


Figure 4.3.1: Bar chart of the mean height of the plant with the treatment of compost.

4.4. Length of water spinach leaves

Similarly, to plant height, the length of leaves was affected mainly by treatment plants and controlled plants with the compost treatment. Therefore, there are statistically no differences in the mean length of water spinach leaves between the compost treatment ($P > 0.05$) based on Table 4.4.1. While the result of Table 4.2.2 and Figure 4.2.1 revealed that the highest length of leaves was exhibited in T2 (61.40 ± 6.07 mm). T1 accumulated the least amount in length of leaves with 56.80 ± 4.97 mm. However, the T3 (58.60 ± 3.78 mm) and T4 (58.00 ± 5.43 mm) results are nearly similar. In addition, Table 4.4.2 below shows a statistically no significant difference using Tukey HSD post hoc analysis in mean length of water spinach leaves between the compost treatment that took the T1, T2, T3 and T4 of treatments.

However, the result contrasts with Pandey et al. (2017) reported that using media from organic matter such as compost is an effective method for water spinach, increasing the leaf yield. A similar result studied by Thakur et al. (2020), state rate of higher growth of leaves length can be achieved using growth media soil and organic manure. Moreover, the result reported by Senevirath et al. (2019) show the highest leaf area of soybean utilising a mixture of 25% of compost with 75% biochar as media to grow. Media planting as the soil needs to mix with treatments to enhance better growth performance of the plant. In addition, compost has treatment using EM solution contain nitrogen, and organic carbon gives better fertility to the soil for plant growth and development. Sharma et al. (2017) studied the effective microorganisms in compost on the growth of Calendula and Marigold that compost as an amendment in soil significantly improved the number of leaves and shoot.

Table 4.4.1: The mean length of water spinach leaves between the treatment using one-way analysis of variance (ANOVA).

ANOVA Length of leaves					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	57.000	3	19.000	0.722	**0.554**
Within Groups	421.200	16	26.325		
Total	478.200	19			

Table 4.4.2: The mean length of water spinach leaves between the treatment using Tukey HSD post hoc analysis.

Treatments	**Length of water spinach leaves (mm) (Mean ± SD.)**
T1	56.80 ± 4.97[a]
T2	61.40 ± 6.07[a]
T3	58.60 ± 3.78[a]
T4	58.00 ± 5.43[a]

[a] Means within the column with a different letter(s) indicate a significant difference between treatments by Tukey test at P≤0.05 (Refer table in appendix F). Each value is expressed as the mean ± standard deviation (n = 5).

Figure 4.4.1 below shows the mean length of leaves, which illustrates the differential between every treatment. In the bar chart graph, a label connects to the means for groups in homogenous subsets displayed by using one-way ANOVA and Tukey HSD post hoc analysis, a refer to the subset for alpha = 0.05.

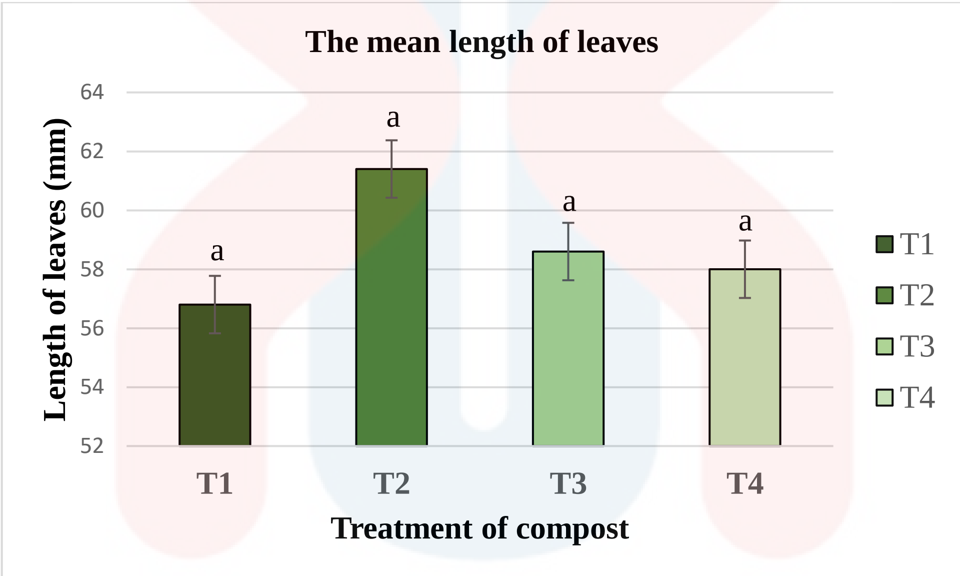


Figure 4.4.1: Bar chart of the mean length of leaves with compost treatment.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, utilising organic kitchen waste for compost making with measuring the effect of kitchen composting was determined through measuring their pH using a 3-way soil meter and screening the physical visual in texture, odour, and colour. The observation of compost for the final product shows all materials decomposed except the eggshells and a few delicate branches. At the same time, the texture is crumbly and smooth with an earthy smell that shows once from characteristics of maturity compost.

In this study, the quality of the water spinach grown in mixed soil and compost as a media plant can be positively affected by modulating the composting process. This would help soil structure, porosity, and density by producing a better plant root environment. The objectives have been successfully achieved by monitoring the effect of the water spinach growth by different treatments of kitchen waste compost using composting process. From the result obtained, T4, T3, and T2 treatment of compost produced better results than controlled treatment (T1) in many things such as length of the roots, plant height, and leaves.

The one-way ANOVA test showed statistically significant differences in compost treatment made with kitchen waste between the mean of water spinach growth of their roots ($p = 0.014$) and height ($p = <0.0001$), which is below 0.05. Then the result of the p-value is statistical significance. Thus, the post-hoc analysis of Tukey's HSD was performed to determine the treatment of compost that contains means of the height and length of roots that are significantly different. However, there were no statistically significant differences in compost treatment made with kitchen waste between the mean of water spinach leaves length ($p = 0.554$), above 0.05.

Furthermore, composting can drastically reduce the volume of waste in the country as a treatment for organic waste. Composting can also offer nutrients suited for agriculture and can be used instead of chemical fertilisers. Compost can also be used as soil additions and is environmentally beneficial, hygienic, cost-effective, and toxic-free.

5.2 Recommendation

Firstly, this is a home lab experiment that gives a limited method. Thus, it can widely use proximate analysis to determine the treatment compost's moisture and ash content. Besides, this research uses a limited sample as media for water spinach growth since it can be conducted using soil only as one treatment to differentiate effect on water spinach growth.

Furthermore, the short duration of composting could not fully degrade all the material, making compost not achieve its stability and maturity. Hence, up to six months of compost degradation will further research the maturity and stability of compost.

Finally, some recommendations can be made in future research; composting municipal solid waste and kitchen waste requires measuring heavy metal content due to its toxicity. Varied composting methods have altered the nutrient status of compost. However, to assure the compost quality, the compost delivered must meet the standard limit. In addition, the application of compost can be modified into education practices such as pest control and fertiliser that will remain to deliver challenges for the future.

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APPENDICES

Appendix A: Turnitin Similarity Report

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ORIGINALITY REPORT

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Appendix B: The collected data of the compost treatment between the parameter effect of the growth water spinach (mm).

Treatment	Length of roots (mm)	Height of plant (mm)	Length of leaves (mm)
T1	117.00	217.00	57.00
T1	75.00	221.00	64.00
T1	86.00	216.00	56.00
T1	61.00	247.00	50.00
T1	99.00	255.00	57.00
T2	158.00	236.00	66.00
T2	73.00	267.00	62.00
T2	135.00	245.00	58.00
T2	107.00	252.00	53.00
T2	95.00	267.00	68.00
T3	105.00	298.00	52.00
T3	130.00	297.00	60.00
T3	108.00	310.00	59.00
T3	115.00	280.00	61.00
T3	113.00	277.00	61.00
T4	138.00	258.00	62.00
T4	121.00	354.00	63.00
T4	153.00	320.00	60.00
T4	135.00	300.00	50.00
T4	150.00	295.00	55.00

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Length of roots	T1	5	87.6000	21.58240	9.65194	60.8019	114.3981	61.00	117.00
	T2	5	113.6000	33.41856	14.94523	72.1054	155.0946	73.00	158.00
	T3	5	114.2000	9.67988	4.32897	102.1808	126.2192	105.00	130.00
	T4	5	139.4000	12.81796	5.73236	123.4844	155.3156	121.00	153.00
	Total	20	113.7000	27.21474	6.08540	100.9631	126.4369	61.00	158.00
Height of plants	T1	5	231.2000	18.39021	8.22435	208.3655	254.0345	216.00	255.00
	T2	5	253.4000	13.64918	6.10410	236.4523	270.3477	236.00	267.00
	T3	5	292.4000	13.72224	6.13677	275.3616	309.4384	277.00	310.00
	T4	5	305.4000	35.21079	15.74675	261.6800	349.1200	258.00	354.00
	Total	20	270.6000	36.62240	8.18902	253.4602	287.7398	216.00	354.00
Length of leaves	T1	5	56.8000	4.96991	2.22261	50.6290	62.9710	50.00	64.00
	T2	5	61.4000	6.06630	2.71293	53.8677	68.9323	53.00	68.00
	T3	5	58.6000	3.78153	1.69115	53.9046	63.2954	52.00	61.00
	T4	5	58.0000	5.43139	2.42899	51.2560	64.7440	50.00	63.00
	Total	20	58.7000	5.01681	1.12179	56.3521	61.0479	50.00	68.00

Appendix C: The ANOVA test result for the length of roots, plant height, and the length of water spinach leaves.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Length of roots	Between Groups	6709.800	3	2236.600	4.861	0.014
	Within Groups	7362.400	16	460.150		
	Total	14072.200	19			
Height of plants	Between Groups	17672.400	3	5890.800	12.068	<0.001
	Within Groups	7810.400	16	488.150		
	Total	25482.800	19			
Length of leaves	Between Groups	57.000	3	19.000	.722	0.554
	Within Groups	421.200	16	26.325		
	Total	478.200	19			

*The mean difference is significant at the 0.05 level.

Appendix D: The Tukey HSD analysis of treatment between mean the length of roots in homogeneous subsets.

Length of roots

Tukey HSD[a]

Treatment	**N**	**Subset for alpha = 0.05**	
		1	**2**
T1	5	87.6000	
T2	5	113.6000	113.6000
T3	5	114.2000	114.2000
T4	5		139.4000
Sig.		0.243	0.266

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 5.000.

Appendix E: The Tukey HSD analysis of treatment between mean the height of plants in homogeneous subsets.

Height of plants

Tukey HSD[a]

Treatment	**N**	**Subset for alpha = 0.05**		
		1	**2**	**3**
T1	5	231.2000		
T2	5	253.4000	253.4000	
T3	5		292.4000	292.4000
T4	5			305.4000
Sig.		0.412	0.057	0.789

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 5.000.

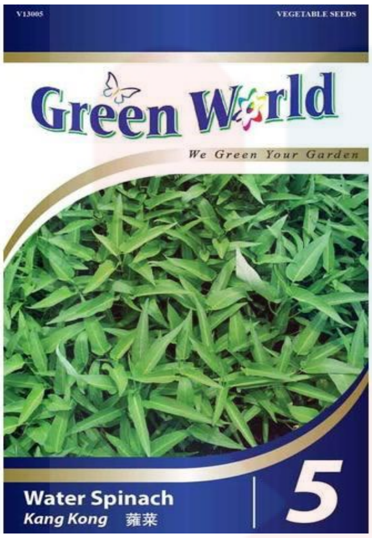
Appendix F: The Tukey HSD analysis of treatment between mean the length of leaves in homogeneous subsets.

Length of leaves

Tukey HSD[a] Treatment	**N**	**Subset for alpha = 0.05**
		1
T1	5	56.8000
T4	5	58.0000
T3	5	58.6000
T2	5	61.4000
Sig.		0.507

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 5.000.

Appendix G: The material used for planting water spinach.



Appendix H: The growth of water spinach with compost treatment

Treatment 1, T1 (control)

Treatment 2, T2

Treatment 3, T3

Treatment 4, T4

Appendix I: The growth of water spinach roots