PRODUCTION OF LIQUID ORGANIC FERTILIZER FROM OIL PALM EMPTY FRUIT BUNCH FIBER WASTE

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ABSTRAK

Malaysia merupakan pengeluar kelapa sawit kedua terbesar di dunia dan menyumbang lebih banyak dalam industri kelapa sawit. Pengurusan sisa minyak sawit yang tidak mencukupi akan mengakibatkan masalah alam sekitar yang serius. Sisa kelapa sawit yang dibuang dalam industri mengandungi nutrien seperti nitrogen, fosforus, dan kalium yang sangat bermanfaat kepada tumbuhan dan berpotensi untuk menambah nilai kepada pengeluaran baja. Sumber semula jadi atau tumbuhan, seperti kelapa sawit, boleh digunakan untuk membuat baja organik. Walaupun kelapa sawit perlu dilupuskan, sisa itu boleh dikitar semula menjadi baja organik. Tujuan kajian ini adalah untuk menentukan formulasi terbaik baja organik cecair (LOF) daripada sisa serat tandan kosong kelapa sawit (OPEFBF) dan mengurangkan jumlah kelapa sawit yang dikeluarkan di FGV Palm Industries Sdn Bhd. Sisa OPEFBF telah dikumpulkan , dan sisa itu dikeringkan di bawah matahari yang panas selama 2 hari untuk mencapai 10% kandungan lembapan. Tiga formulasi LOF iaitu formulasi A, formulasi B dan formulasi C dengan menggunakan OPEFBF sebagai sampel utama telah disediakan. Semua formulasi diinkubasi selama 14 hari menggunakan sistem anaerobik. Tiga formulasi LOF dan LOF komersial telah dihantar untuk analisis nutrien untuk memeriksa kandungan Nitrogen, Fosforus dan Kalium (NPK) dengan menggunakan Spektrometri Pelepasan Optik Plasma Berganding Secara Induktif (ICP-OES). Kesemua LOF telah dianalisis untuk jumlah pepejal larut (TDS) dan kekonduksian elektrik (EC) menggunakan meter kekonduksian jumlah pepejal terlarut dan elektrik mudah alih. Keputusan menunjukkan bahawa baja komersial memperoleh nilai NPK tertinggi dan nilai terendah dalam TDS dan EC berbanding tiga formulasi LOF. Ini mungkin bahan yang digunakan dalam pengeluaran baja komersial kaya dengan kandungan nutrien daripada tiga formulasi LOF. Formula A sebaliknya hampir setanding dengan LOF komersial kerana ia hanya sedikit di bawah LOF komersial. Nilai NPK untuk formulasi A berada di tempat kedua selepas baja komersial dan ia juga tinggi sedikit dalam nilai TDS dan EC berbanding baja komersial. Ringkasnya, formulasi A telah dikenal pasti sebagai formulasi terbaik LOF dalam projek ini.

ABSTRACT

Malaysia is the second largest oil palm producer in the world and contribute more in oil palm industry. Inadequate palm oil waste management will result in serious environmental problems. Oil palm wastes discharged in the industry contain nutrients such as nitrogen, phosphorus, and potassium that are extremely beneficial to plants and have the potential to add value to fertilizer production. Natural resources or plants, such as oil palm, can be used to make organic fertilizers. Despite the fact that oil palm should be disposed of, the waste can be recycled into organic fertilizer. The purpose of this study were to determine the best formulation of liquid organic fertilizer (LOF) from oil palm empty fruit bunch fiber (OPEFBF) waste and to reduce the amount of oil palm produced in FGV Palm Industries Sdn Bhd. The OPEFBF waste was collected, and the waste was dried under hot sun for 2 days to achieve 10% of moisture content. Three formulations of LOF which are formulation A, formulation B and formulation C by using OPEFBF as main sample were prepared. All formulation were incubated for 14 days using anaerobic system. The three LOF formulations and commercial LOF were sent for nutrient analysis to check for Nitrogen, Phosphorus and Potassium (NPK) content by using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES). All of the LOFs were analyzed for the total dissolve solid (TDS) and electrical conductivity (EC) using portable total dissolve solid and electrical conductivity meter. The results showed that commercial fertilizer obtained the highest NPK values and the lowest value in TDS and EC as compared to the three LOF formulations. This could be the ingredients used in production of commercial fertilizer were rich in nutrients content than the three LOF formulations. Formulation A on the other hand was almost on par with the commercial LOF as it was just slightly below commercial LOF. The NPK values for formulation A was in second after commercial fertilizer and it also slightly high in TDS and EC values compared to commercial fertilizer. In short, formulation A had been identified as the best formulation of LOF in this project.

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LIST OF SYMBOLS

NH_4	Ammonia
Ca	Calcium
C	Carbon
℃	Celcius
Mg	Magnesium
N	Nitrogen
%	Percentage
P	Phosphorus
K	Potassium
S	Sulphur
Zn	Zinc

LIST OF ABBREVIATIONS

ACC	1-minocyclopropane-1-carboxylate
ABA	Abscisic acid
BOD	Biological oxygen demand
COD	Chemical oxygen demand
CL	Compost leachate
CT	Compost tea
CPO	Crude palm oil
EM4	Effective microorganism 4
EC	Electrical conductivity
EFB	Empty fruit bunches
FFB	Fresh fruit bunches
GA	Gibberellic acid
IAA	Indole-3-acetic acid
ICP-OES	Inductively coupled plasma-optical emission spectrometry
IU	International unit
LOF	Liquid organic fertilizer
MF	Mesocarp fibre
NPK	Nitrogen phosphorus potassium
OPA	Oil palm ash
OPEFBF	Oil palm empty fruit bunch fiber
OPF	Oil palm fronds
OPT	Oil palm trunks
PKM	Palm kernel meal
PKS	Palm kernel shell
POME	Palm oil mill effluent
PGPR	Plant growth promoting rhizobacteria
PFF	Pressed fruit fiber
POPF	Pruning oil palm frond
TDP	Total dissolved solids
TDM	Total dry matter
WEP	Waste end processing

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Fertilization is a critical component of agricultural production management. Fertilizers are compounds that supply plants with essential nutrients, primarily phosphorus, potassium, and nitrogen. Additionally, it is frequently utilised to supply important nutrients to plants in order for them to grow more. Indeed, the yields of the majority of crop plants increase linearly in proportion to the amount of fertiliser absorbed. However, the apparent deficiency of nitrogen accessible to plants in organic fertiliser, produced by the slow rate of mineralization, results in poorer crop yields in fields treated with organic fertiliser compared to those treated with chemical fertiliser (Riddech et al., 2019).

Fertilizer was offered in a variety of forms, including inorganic, organic, and biofertilizer. The majority of organic fertilisers are made entirely of organic ingredients, as opposed to chemically generated materials. Organic liquid fertilisers contain vital plant nutrients and beneficial microbes that aid in the recycling of organic matter. Microorganisms contribute significantly to the fermentation phase by decomposing substrates (Riddech et al., 2019). Due to the fact that the ingredients in liquid fertilisers have already dissolved, they are more easily absorbed by plants. Additionally, because the material is dissolved, it is more efficient than solid fertiliser. Liquid organic fertiliser contains a binding agent that helps plants to rapidly absorb fertiliser solutions sprayed to the soil's surface (Solihin et al., 2019). Thus, the addition of organic liquid fertiliser and nitrogen, potassium, and phosphorus to the soil is expected to improve the soil's physicochemical analysis and stimulate spinach growth.

The palm oil plantation in Malaysia is the most significant resource, having contributed to the country's agricultural and economic transformation. However, the existence of these oil palm trash has created a serious disposal issue (Sulaiman et al., 2013). Human activity produces waste as an inescapable byproduct. Globally, agricultural and industrial waste management is a big concern (Hanafi et al., 2014). Pollution dangers arise from industrial waste processing in neighbouring locations. Recycling waste is a waste management technique that enables garbage to be treated and resources to be managed. These ideas are equally applicable to agricultural and industrial trash such as palm oil dregs as they are to urban rubbish. According to Madusari (2019) oil palm fruit fibre is a type of palm oil solid waste generated by a press machine. Oil palm fruit fibre is spun like yarn and contains cellulose, hemicellulose, lignin, nitrogen, phosphorus, and micronutrients, making it perfect for processing into organic liquid fertiliser. Palm oil biomass fibres are continually contained in oil palm fractures throughout trimming operations, in oil palm stems treated following replanting (after 25 years), and in periodic processing (Dungani et al., 2018). Due to the fact that oil palm fruit fibre is a naturally occurring byproduct, it might be used as a liquid organic fertiliser.

Riddech et al. (2019) previously employed sugarcane leaf waste, molasses, and distillery slop as organic substrates for the production of liquid organic fertiliser. Molasses and distillery slop are carbon-dense agricultural by-products. Molasses is a dark-coloured, sweet, and syrupy byproduct of sugarcane and sugar beet sugar extraction that is high in vitamins and minerals. Slop from distilleries, a byproduct of the ethanol production process, has increased quantities of organic contaminants. Sugarcane leaves are a byproduct of sugarcane harvesting and contribute organic materials to the ecosystem (Riddech et al., 2019).

While various studies have been undertaken on the impacts of liquid organic fertiliser on plants, research on the consequences of utilising a liquid fertiliser with agro-industrial waste as the substrate remains lacking. Thus, the purpose of this study is to construct a liquid organic fertiliser from agro-industrial waste derived from oil palm fibres and to evaluate the fertilizer's performance in encouraging plant development.

1.2 Problem Statement

Each year, the globe generates 998 million tonnes of agricultural waste, and Malaysia disposes of 1.2 million tonnes of agricultural waste in landfills. This is because agriculture is critical to meeting human needs and maintaining our way of life. Agro-waste is predicted to account for 15% of total garbage produced in Asia, with agricultural waste accounting for around 0.122 (kg/cap/day) in Malaysia in 2009 and expected to reach 0.210 (kg/cap/day) by 2025. (Neh et al., 2020). An oil palm plantation is capable of producing a large amount of total dry matter (TDM). TDM produces about 55 tonnes of TDM per hectare annually. TDM is used in palm oil processing mills at a rate of 5.5 tonnes per hectare per year for palm oil and palm kernel oil (10% of the TDM), while the remaining 90% of TDM or biomass in the form of lignocellulose is accessible for use (Liew et al., 2017).

A considerable disposal challenge has emerged as a result of the existence of oil palm garbage. The essential concepts of waste management are to minimise and recycle waste, to recover energy from trash, and to properly dispose of waste. Additionally, these concepts apply to agro-industrial wastes such as palm oil residues. It simply cannot afford to squander residues when there is a more economically feasible alternative. Prior to considering the energy recovery potential in the palm oil sector, it is necessary to analyse the existing usage and disposal of mill leftovers (Abdullah et al., 2013). Numerous waste products are formed in palm oil mills during the conversion of fresh fruit bunches (FFB) to crude palm oil (CPO), including empty fruit bunches (EFB), mesocarp fibre (MF), palm kernel shell (PKS), palm kernel meal (PKM), and palm oil mill effluent (POME) (Hambali et al., 2017).

Inorganic fertiliser use has been chastised for posing a slew of health and environmental hazards. Additionally, inorganic fertilisers contaminate groundwater and are hazardous to the ecosystem. Inorganic fertilisers used continuously and consistently cause plant tissues to absorb and deposit heavy metals, lowering crop nutrition and grain quality. Soil, air, and water have been contaminated as a result of excessive inorganic fertiliser use due to nutrient leaching, soil physical features deterioration, toxic chemical accumulation in bodies of water, and other causes, as well as serious environmental concerns and biodiversity loss. As a result, agrochemicals are a substantial and dominant cause of pollution in developing countries, posing grave health concerns to humans and cattle (Kakar et al., 2020). Use of inorganic fertilisers on a long-term basis can impair the soil texture, microorganisms, and pH, resulting in lower productivity. The negative consequences of inorganic fertilisers motivate researchers and practitioners to create alternative fertilisers, particularly organic fertilisers, that are projected to boost plant output while minimising the negative impacts of inorganic fertilisers (Madusari, 2019).

Thus, in the modern period, a new farming method called as organic agriculture, sustainable agriculture, or ecological agriculture was established in order to offset and remove the detrimental effects of synthetic fertilisers on human health and the environment. Organic fertilisers are less expensive and more accessible than chemical fertilisers. Organic matter is what determines the fertility of the soil. Microbial fertilisers are non-toxic, non-polluting, and cost-effective, and they are vital for plant nutrition. On the other hand, inorganic fertilisers are infamous for their high cost and potential for environmental damage if not adequately controlled. All of these factors lead to agricultural production reductions as a result of soil degradation and nutrient imbalances (Chandini et al., 2019).

Generally, liquid organic fertilisers comprise a low concentration of chemical compounds and an adequate nutrient content to suit the nutritional requirements of the plant. If there is an abundance of fertiliser in the soil, the plants can easily manage its uptake (Hendarto et al., 2018). In compared to traditional organic fertilisers, liquid organic fertilisers have a higher concentration of organic matter and soluble nutrients, which may contribute to soil sustainability and plant health. Additionally, combining irrigation and fertilisation patterns may improve nutrient usage efficiency and reduce nutrient waste. Additionally, the unique components found in liquid organic fertilisers, such as chitin, humic and fulvic acids, as well as other biopolymers, can work as biostimulants for plants (Ji et al., 2017).

1.3 Objectives of Study

The objectives of this research are:

i. To evaluate the nitrogen, phosphorus and potassium (NPK) values of liquid organic fertilizer.
ii. To determine the best formulation of liquid organic fertilizer from oil palm empty fruit bunch fiber (OPEFBF) waste based on three formulations.

iii. To evaluate the performance of liquid organic fertilizer to the plant and soil.

1.4 Scopes of Study

i. Collecting sample of oil palm empty fruit bunch fiber (OPEFBF) waste from FGV Palm Industries Sdn Bhd.
ii. Preparing three formulations of liquid organic fertilizer from OPEFBF waste and fermented for 2 weeks.
iii. Analyse the nutrient content of liquid organic fertilizer using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES).
iv. Evaluate the effectiveness of liquid organic fertilizer to the Alternanthera sissoo (Sissoo Spinach) and *Ficus elastica* (Rubber Plants).
v. Analyzing the pH, temperature and moisture content of soil in 4 weeks.

CHAPTER 2

LITERATURE REVIEW

2.1 Liquid Organic Fertilizer

In recent years, the contemporary agriculture sectors have experienced a major increase in the use of liquid organic fertilisers. Because liquid organic fertilisers contain growth-promoting macronutrients, micronutrients, fulvic, and humic acids, they are generally utilised to develop high-yielding plants such as healthy green lawns and robust plants (Akyol et al., 2013). Because liquid organic fertiliser may be diluted, it is more readily absorbed by plants and more inexpensive to use. Composting the basic materials dissolved in water and augmented with a variety of bioactivators enables the production of these fertilisers to occur fast and with high quality (Rahmad et al., 2019). The conventional organic fertiliser made from market trash also owns liquid organic fertilisers. On the other side, manufacturing or processing wastes into fertiliser can help reduce pollution and extend the life of WEP (Garbage End Processing) sites by reducing the amount of waste put there. Additionally, waste processing enables the reduction of unemployment. A typical market can create daily wastes of up to 100 m^3, meaning that the capacity for manufacturing liquid organic fertilisers from traditional market wastes must be huge to ensure their long-term supply (Hendarto et al., 2018).

2.1.1 History and Background

Organic agriculture is a fast increasing industry in the Philippines today, partially because it addresses waste disposal difficulties by converting biodegradable wastes into organic compost, ensuring the supply of organic fertiliser for crop development. Additionally, due to the absence of chemical application, organic vegetable cultivation enables the production of high-quality vegetables throughout the year. It also contributes to the rehabilitation and preservation of our croplands' fertility, which has been deteriorated or is at risk of deterioration as a result of intense crop production and poor soil management techniques. Organic fertilisers obtained from animals provide more total biomass than vegetal-derived fertilisers, owing to the enhancement of new organs and fibrous root development. On the other hand, organic fertilisation boosted plant biomass in the same way as cow dung and compost generated from municipal solid waste and pruning debris did. It is worth noting, however, that in this experiment, animal excrement was predigested to form a liquid fertiliser, which boosted nutrient availability in comparison to direct application of cow manure (Martnez et al., 2016).

In Indonesia, the most extensively disseminated liquid organic fertiliser is made by commercial traders who already have a brand name and a well-known trademark for liquid organic fertiliser produced by small-scale farmer organisations. Additionally, the influence of an organic liquid fertiliser of excellent quality differs by neighbourhood. Liquid organic fertiliser, according to some crop growers' experience, has a minor influence on rice production improvement. Among the challenges faced by liquid organic fertilisers are their restricted availability, the volume and composition of the nutrients they contain, and their manufacturing procedures, which remain primitive (Munir, 2018).

2.1.2 Process in Production of Liquid Organic Fertilizer

The use of liquid waste as a liquid organic fertiliser is constrained by a dearth of technology capable of creating fertiliser with excellent nutritional and aesthetic values. Liquid waste fermentation technique is expected to be capable of treating liquid waste from poultry slaughterhouses. However, there are concerns about this liquid waste's features, as they are highly different and dissimilar to those of other liquid wastes. These distinctions may result in variances in the performance of the fermentation process (Sastro et al., 2013). Rubber effluent is odorous, depletes soil nutrients, and contaminates water when it is merely discharged into the environment. Converting rubber manufacturing liquid waste into liquid compost fertiliser is one way for tackling issue. Compost liquid is a material created from plants that has been developed to improve the physical, chemical, and biological qualities of the soil. Composting is the process by which organic matter is decomposed or destroyed by a diverse range of organisms in a specific setting, resulting in compost that has no detrimental effect on the soil. Composting can be facilitated by the addition of a biofertilizer as a decomposer, which improves the quality of the compost and accelerates the decomposition process. EM4 (Effective Microorganism 4) is a readily available and inexpensive decomposer. (Ali et al., 2019).

2.1.2.1 Fermentation

When the conditions for fermentation of organic materials are favourable, microorganisms perform admirably. The fermentation process will take place in a semi-aerobic environment with a pH of 3-4, a high salinity and sugar content, a moderate water content of 30%-40%, fermentation microorganisms, and a temperature range of 30-50°C. (Ali et al., 2019). It has been observed that fertilising with rapeseed cake, soybean meal, or other meals can enhance the number and activity of microbes in the soil, hence improving the quality of the plants. In many places of China, composting fermenting meal fertiliser is still a traditional way of producing fertiliser. This approach, however, has some disadvantages, including a protracted fermentation period (one to six months) and high nitrogen loss (about 30%–50% throughout the composting process). As a result, nitrogen cannot be used properly or substantially for plant growth, rendering meal ineffective for this purpose (Wang et al., 2014).

Using organic material obtained from animals, such as fisheries waste, may be an alternative. Fermentation may result in the generation of liquid fertiliser in this scenario. However, fishery waste cannot be used directly as liquid fertiliser because the waste contains organic matter in the form of fat and protein that the plant cannot absorb. Organic debris in wastewater should be broken down into simpler organic molecules to enable plants to absorb the nutrients included in organic liquid fertiliser more readily (Widyastuti et al., 2018). In Thailand, liquid organic fertilisers derived from agricultural residues and industrial waste are gaining popularity. These fertilisers are created using basic fermentation techniques using organic waste as a carbon source. Organic liquid fertilisers contain vital plant nutrients and beneficial microbes that aid in the recycling of organic matter. By decomposing the substrates, microorganisms contribute significantly to the fermentation process. Liquid organic fertilisers contain phytohormones such as auxin and cytokinin, organic acids, and growth stimulants at the completion of the fermentation process (Phibunwatthanawong et al., 2019).

Apple fruit fermentation is an example of fermentation in liquid organic fertiliser. Apple fruit fermentation is a quick and easy way to create a liquid organic fertiliser from naturally fallen fruits or those that have separated during crop thinning. Fermentation of apple fruit accelerates the decomposition of organic matter, releases minerals, biologically active compounds, and secondary metabolites, and increases soil microbial growth. Thus, apple fruit fermentation may contribute nutrients, regulators, and other helpful substances that promote and regulate plant growth and development. Additionally, its application can assist in reducing the accumulation of decaying fruit in an orchard environment and in preventing soil degradation. Although little is known about the mechanisms underlying apple fruit fermentation's effects on plant growth and development, a variety of other plant waste products, such as cut shoots, drooping flowers, and plant cuttings, are being evaluated for their potential to similarly enhance plant development and orchard soil quality (Zhang et al., 2016).

2.1.2.2 Composting

Figure 2.1 shows composting process of converting organic matter of plant and animal origin into manure. Composting generates humus and plant nutrients, as well as carbon dioxide, water, and heat. Composting requires oxygen to be completed, which is referred to as aerobic composting. Composting is a method of controlled decomposition that replicates nature's breakdown process. Composting is the process of turning raw organic matter into biologically stable humic compounds suited for a wide range of soil types and plant applications. Composting results in the production of organic fertilisers. Organic fertilisers are made from a variety of sources, including vegetables, fruits, and animals. Organic fertilisers are crucial in agriculture since they enrich the soil while posing no threat to ground water or plants (Hamid et al., 2019).

Composting bio-waste produces organic liquid fertiliser as a byproduct. Compost liquid fertiliser may operate as a biostimulant, boosting crop output and quality, suppressing pathogenic bacteria on the plant, giving the plant with water-soluble nutrients, and enriching the soil with the microorganism. Compost liquid fertiliser contains a high concentration of potassium (K), magnesium (Mg), calcium (Ca), sodium (Na), and a range of other microelements. It contains humic acids, which help balance vitamin and macronutrient absorption. Compost tea is a liquid extract obtained by combining compost with a specified solution (CT). Solid and liquid compost fertilisers derived from biowaste should be marketed as organic fertilisers (Lim et al., 2019).

Composting can be accomplished by a variety of microorganisms, including Biosca and Trichoderma harzianum mushrooms. Biosca is a liquid decomposer containing a diverse array of microorganisms that aid in the breakdown or decomposition of organic waste into fertiliser. These nitrogen-fixing microbes are lignolytic, cellulolytic, pretiolytic, lipolytic, aminolytic, and nonsymbiotic. In one study, Biosca was used to turn leachate wastewater (liquid heaps of organic debris) into a liquid organic fertiliser with a high nutrient content for plants (Rahmad et al., 2019). At its most fundamental level, composting requires creating a heap of moist organic matter known as green trash (leaves, food waste) and waiting for the components to breakdown into humus over a period of weeks or months. Composting in the current period is a multi-step, highly regulated process that involves precise inputs of water, air, and carbon and nitrogen-rich materials. Shredding the plant materials, adding water, and regularly rotating the mixture to maintain sufficient aeration all contribute in the decomposition process. Worms and fungus continue to aggregate the material. Bacteria that do not require oxygen to survive (aerobic bacteria) and fungus regulate chemical reactions by converting inputs to heat, carbon dioxide, and ammonium (Abilasha et al., 2018).

Figure 2.1 Composting process

2.1.3 Common Organism Used in Liquid Organic Fertilizer

Liquid organic fertilisers containing stillage and vermicompost promoted tomato root growth and increased the diversity of the soil's Eubacterial and Archaeal microbial communities, which was consistent with previous findings that liquid residues from lipopeptide production can promote tomato growth and increase the diversity of the soil's microbial community, as well as associated enzyme activation (Ji et al., 2017). Liquid organic fertilisers are made up of important plant nutrients and beneficial microbes that aid in the organic matter recycling process. Microorganisms are crucial in the breakdown of substrates during the fermentation process. At the conclusion of the fermentation process, liquid organic fertilisers contain phytohormones such as auxin and cytokinin, organic acids, and plant growth stimulants (Phibunwatthanawong et al., 2019).

Beneficial microorganisms contained in biofertilizers have the potential to increase soil nutrient availability through nitrogen fixation, phosphorus metabolism, and the production of plant hormones such as indole-3-acetic acid (IAA), gibberellic acid (GA), abscisic acid (ABA), 1-minocyclopropane-1-carboxylate (ACC) deaminase, salicylic acid, and siderophore. Klebsiella sp. is classed as a diazotroph or nitrogen-fixer due to its features and function as a plant growth promoting rhizobacteria (PGPR). It is primarily utilised to generate liquid organic fertiliser and bio-fertilizer (Nhu et al., 2018).

2.1.4 Production of Liquid Organic Fertilizer

Organic fertiliser is purely organic in composition. It comes in a variety of forms, including both solid and liquid organic fertiliser. Organic raw materials can be derived from organic waste generated by humans or from abandoned organic garbage. For example, in Indonesia, coconut husk and cane skin waste are plentiful, serving as a source of liquid organic fertiliser. According to a study, combining solid organic fertiliser created from bakery waste with liquid organic fertiliser, goat droppings, and coconut husk resulted in enhanced mustard yield when compared to utilising solely solid organic fertiliser made from bakery waste. Application of liquid organic fertiliser derived from water hyacinth waste enhanced soybean production by 21.6 percent as compared to no application of LOF derived from water hyacinth waste (Jajuk et al., 2017). Figure 2.2 shows production of liquid organic fertilizer (LOF).

Agricultural waste refers to agricultural by-products that are not properly utilised or disposed of, such as vegetable waste, rotten fruit, coconut fibre, agricultural waste, fisheries waste, and household waste, all of which contribute to environmental pollution, disease transmission, and interference with environmental cleanliness. To assist in reducing agricultural product waste, trash can be used as organic fertiliser to enrich the soil. According to research, the highest concentration of macro-nitrogen (N) is found in vegetable liquid waste, the highest concentration of phosphate (P) is found in vegetable and fruit waste, and the highest concentration of potassium (K) is found in fruit waste, while the microelements calcium (Ca) is found in vegetable and fruit waste, magnesium (Mg) is found in fruit waste, iron (Fe) is found in vegetable and fruit waste, zinc (Zn) is found in cow urine, and ammonia Rumen animals are discarded from slaughterhouses but still contain nutrients, bacteria, and undigested food that can be repurposed. One method of recycling slaughterhouse waste is to convert rumen waste into liquid organic fertiliser. This usage will help to decrease the risk of environmental and water pollution caused by the build up of rumen contents in slaughterhouse waste (Lesik et al., 2019).

Figure 2.2 Production of liquid organic fertilizer (LOF)
Source: Mostafazadeh et al. (2019)

2.1.4.1 Sewage Sludge

In recent years, massive amounts of sewage sludge production have become a severe concern in a number of countries. In growing countries such as China, sewage sludge production is expanding in tandem with wastewater discharge, resulting in extremely serious environmental damage. As a result, the problem of sludge pollution must be addressed urgently. Sewage sludge is a type of biomass that arises from wastewater treatment; it has a moisture level of up to 80% and a high organic matter content. As a result, it is particularly prone to rot and has a significant odour problem. With the increased output of sewage sludge, interest in this technique of disposal is increasing. Figure 2.3 shows sewage sludge disposal data. Now, sludge can be disposed of via landfill, incineration, or agricultural use. However, these traditional techniques of sewage sludge disposal are insufficient to meet the treatment requirement, as the sludge still poses a major risk to human health and the environment (Sun et al., 2013).

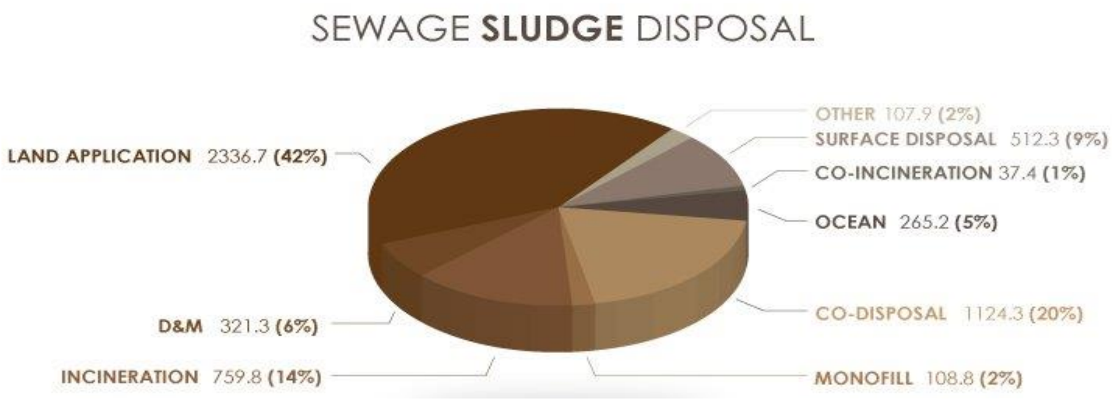

Figure 2.3 Sewage sludge disposal data
Source: Carlson (2021)

Chemical fertilisers predominantly constituted of nitrogen, phosphorous, and potassium (NPK) have had a substantial impact on the environment over the years due to their widespread use on a variety of lands throughout the world. This demonstrates the critical nature of recycling many types of biomass waste into organic fertilisers, including animal manure, sewage sludge, and food waste. Organic waste appropriate for agricultural fertiliser production can be categorised into three categories: animal-derived organic waste (manure), compost (organic waste and food waste from plants), and urban garbage (sewage sludge and household waste). These wastes are treated to boost their nutritional value and agricultural value, thereby fostering a more biodiverse economy and environment (Chew et al., 2019). Because sewage sludge contains a significant amount of nitrogen, phosphorus, and organic matter, it has potential fertiliser characteristics and can be utilised to enhance agricultural soils. Sludge from sewage treatment plants can operate as a moisture source and a pH regulator in certain circumstances. Along with the nutrients necessary for plant growth, sludge may contain traces of heavy metals and other contaminants (Iticescu et al., 2018).

Prior to applying sewer sludge to the natural environment, the substance must be stabilised and processed using biological, chemical, thermal, or other processes to minimise putrefaction and eliminate any damage to the environment or human health. The use of sewage sludge as a fertiliser minimises the requirement for mineral fertilisers and supplies biogenic ingredients to terrestrial ecosystems. Additionally, operating energy crop plantations is less expensive (Wierzbowska et al., 2016).

2.1.4.2 Manure

Organic manure has a number of disadvantages, including a low nutritional content, a sluggish rate of decomposition, and variable nutrient compositions depending on the organic materials utilised. However, organic manure has various benefits, including a balanced nutrient supply, higher soil nutrient availability due to increased soil microbial activity, the breakdown of hazardous components, improved soil structure and root development, and greater soil water availability. Organic manure improves crop yield, nitrogen usage efficiency, and soil health when compared to artificial fertilisers in a study conducted on tomatoes (Lycopersicon esculentum) and corn (Zea mays) grown in acidic soil. Numerous research conducted in agricultural fields have indicated that combining chemical fertilisers and organic manure decreases chemical fertiliser harm while increasing crop output (Han et al.,2016). Organic manure has the capacity to decrease the soil's pH and boost the electrical conductivity of nutrient absorption (Purbajanti et al., 2020). Organic liquid fertilisers such as poultry manure tea and compost tea have been shown to contain a considerable amount of nitrogen in the inorganic form of ammonia and can deliver nutrients to plants nearly quickly, similar to chemical fertilisers (Jigme et al., 2015).

2.1.4.3 Agro Industrial Waste

Organic agriculture strives to produce high-quality food while simultaneously being environmentally conscious and protecting soil fertility through resource efficiency.

Organic agriculture promotes nutrient recycling in order to minimise nutrient imports. Organic waste application to soil is an efficient way to preserve soil organic matter, improve soil fertility, and feed nutrients to plants. Organic fertilisers are composed of natural ingredients and hence more environmentally friendly than chemical fertilisers. Numerous agricultural wastes, including animal wastes, agricultural and industrial effluents, municipal wastewater, and nutrient-fortified biosolids. This category includes around 15 million tonnes of urban garbage, 20 million tonnes of crop residue, and 275.5 million tonnes of animal manure (Buang et al., 2018). Figure 2.4 shows the examples of agro industrial waste. Olive pomace is a substantial organic agro-industrial waste in Mediterranean countries, with a high organic matter content (about 90%) that can be recycled effectively through composting for use as agricultural fertiliser. Olive pomace is a semisolid fraction formed during two-phase centrifugation following the extraction of olive oil. It is produced in significant numbers within a brief period of time (October-November), and inappropriate disposal might have a negative influence on the environment. This is due to the phytotoxic and antibacterial characteristics of phenolic chemicals and lipid fractions. Composting pre-processed olive pomace with on-farm vegetable residue compost may be a practical means of recycling this waste, resulting in a biofertilizer with an appropriate degree of stability and maturity. When compared to the initial material, composting olive pomace can result in a drop in the C/N ratio and an increase in microbial activity (Diacono et al., 2019).

Fertilizer ingredient costs continue to rise everyday, putting small and marginal farmers out of reach, exposing the detrimental effects of uneven fertiliser use. Due to the ongoing usage of NPK fertilisers with a high analysis, sulphur and micronutrient shortages have developed. Thus, conservation and efficient use of natural resources, such as organics obtained from agricultural wastes, are required to maintain sustainable high yields in food and nutritional security while also ensuring environmental safety (Pal et al., 2014). Without treatment, agricultural effluents lead to environmental contamination. When appropriately processed, these nutrients, referred to as nutrient-dense wastes, can be transformed into a valuable source of organic fertiliser (Elaiyaraju et al., 2016).

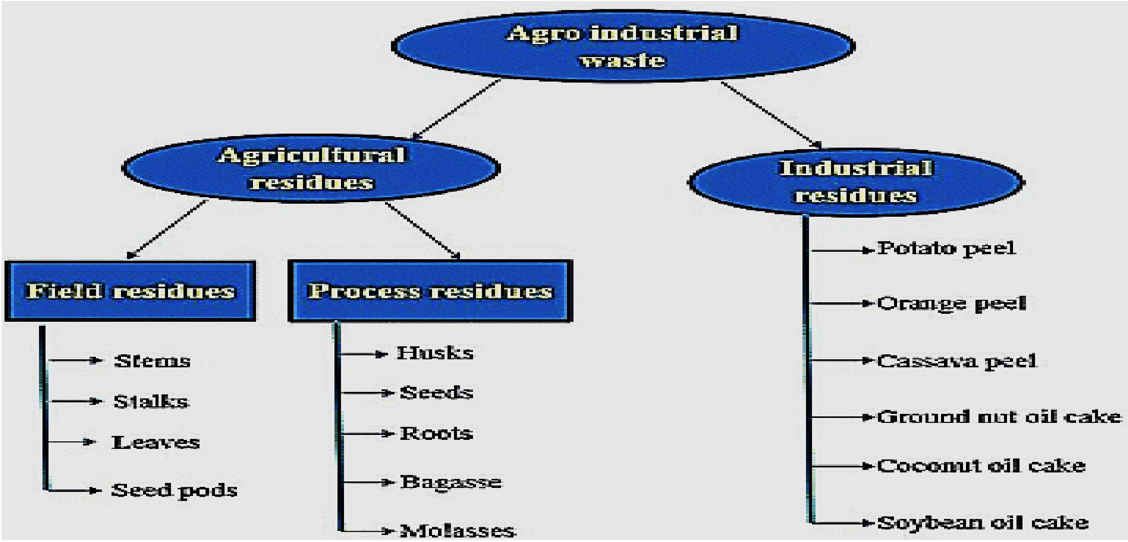

Figure 2.4 Examples of agro industrial waste
Source: Sadh et al. (2018)

2.1.4.4 Food Waste

After consumption, food waste is defined as any food substance that is wasted or repurposed. Food waste occurs in a variety of locations, including homes, markets, hawker centres, supermarkets, and food courts. To preserve a safe and healthy environment, these wastes must be eradicated. Composting garbage and creating compost for field crop production can help achieve these objectives. Food waste contains a considerable amount of energy, making it a good choice for energy generation while also assisting in trash stabilisation. Organic or bio-waste makes up more than a third of home waste. Organic matter loss impoverishes soil directly, degrades agricultural land, diminishes forest cover, draws up stored carbon deposits (oil, gas), exacerbates socioeconomic inequality in countries that generate these goods, and contributes to climate change, among other negative repercussions (Amra et al., 2018).

Numerous researches have reported numerous techniques for converting food waste to fertiliser. Compost-free technology is one method. Compost-free technique utilises heat and enzymes to turn chopped food waste and other green wastes into organic fertiliser. Figure 2.5 shows the process of converting the food waste into organic fertilizer. Another study proved that the Berkeley and Bokashi processes for creating fertiliser from food waste may be utilised successfully in Malaysia. This study revealed that peanut crops fertilised with Berkeley and Bokashi fertilisers develop more rapidly, have a greater nodulation increment, and yield more than crops planted with inorganic fertiliser (Amiruddin et al., 2020). Berkeley's process is called hot composting, often known as aerobic food waste treatment. It is a biological process in which waste material is broken down into hygienic, humus-rich compounds in the presence of oxygen by a variety of microorganisms including bacteria and fungi. It has been established as the most effective technique of disposing of green waste and food waste. The Bokashi process is a sort of anaerobic digestion. It is one of a variety of products that include beneficial microbes. Anaerobic Bokashi is fermented in closed containers at a low temperature (Daud et al., 2016).

Figure 2.5 Process of food waste into organic fertilizer

Source: Chandan (2020)

2.1.5 Sources That Enhance Production of Liquid Organic Fertilizer

Organic fertilisers are one of the inputs towards the organic farming system's production expenses. Organic fertilisers are frequently deficient in nutrients and must be applied in considerable quantities to meet crop nutritional demands, rendering them ineffective and inefficient at times. As a result, liquid organic fertilisers are produced to aid in crop growth and yield enhancement. The utilisation of locally sourced organic material as the liquid organic source is favourable and practically suitable to smallholder farmers. Thus, determining the nutritional content of these indigenous materials is crucial for the production of a high-quality liquid organic fertiliser (Sopha et al., 2019).

2.1.5.1 Molasses

Molasses is a fermentation byproduct that is utilised in the food sector for distilleries, sugar manufacture, and yeast production. However, these methods produce significant amounts of effluent. Molasses wastewater is dark brown in colour and contains a high concentration of naturally resistant chemicals, such as melanoidins, and its pigment is difficult to breakdown by microbes. Additionally, the liquid waste from molasses is acidic, with a pH of 3.5 to 4.5, has a high concentration of organic and soluble components, and has a high biological oxygen demand (BOD) and chemical oxygen demand (COD) (COD). Molasses wastewater treatment has grown complicated due to the presence of poorly biodegradable chemicals such as melanoidins. However, molasses wastewater is a great source of minerals such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulphur (S), and micronutrients (Li et al., 2020). The agricultural business generated trash such as distillery slop, molasses, and bio-methane effluent. They are nutrient-dense and can be used to make organic fertilisers. As a result, the industries' objective is to reduce waste by converting to high-value agricultural products (Riddech et al., 2019).

Each year, enormous amounts of molasses are produced and used in a range of sectors, including animal feed, ethanol, and fertilisers. When employed in agriculture, sugar beet molasses enhances the efficiency of nutrient element uptake and soil biological activity. Historically, molasses was employed as a fertiliser and soil improver, particularly on sandy soils and soils with a poor structure. Molasses provides carbohydrates and affects the carbon: nitrogen ratio in the soil, altering soil microbial ecology and lowering parasitic nematodes on plants, among other favourable impacts on plant growth. The use of filter mud cake and molasses resulted in increased nitrogen, phosphorus, and potassium (NPK) absorption and production. Molasses improves soil aggregation and minimises crusting on the surface of difficult-to-set soils. Molasses sterilises the soil to a certain extent and promotes nitrogen fixation (Pyakurel et al., 2019).

2.1.5.2 Urea

Nitrogen is the most important nutrient for plants. Nitrogen is a crucial ingredient for healthy plant growth and development. Farmers frequently fertilise sweet corn excessively, thereby degrading soil fertility. Amounts of urea should be applied in such a way that soil fertility is not jeopardised. Nitrogen insufficiency is a more frequent limitation than other components on sweet corn productivity. It is expected that adding urea fertiliser, which contains 46% nitrogen, can alleviate the sweet corn plant's N nutrient shortage (Pangaribuan et al., 2018). Urea ammonium nitrate is the most often used liquid nitrogen fertiliser. Urea ammonium nitrate is a non-pressurized solution used extensively in agriculture. Growers have had access to a multipurpose liquid urea and ammonium nitrate mixture for a long period of time. It supplies plants with quick and sustained nutrition supply via a mixture of three types of nitrogen. While nitrate-nitrogen gives an instantaneous response, ammonic-nitrogen provides a more protracted response and continual feeding via the water-soluble organic nitrogen in urea. Liquid urea is a diluted urea solution. The advantages of liquid urea include a slower rate of uptake by the plant, which aids in preserving the soil-plant nitrogen balance. It is recommended to administer liquid urea during the warm season to swiftly address nitrogen shortage (Walsh et al., 2016).

2.1.6 Comparison Between Two types of Natural Bioactivators

2.1.6.1 Noni Fruits

Noni is the popular name for Morinda citrifolia, a small to medium-sized tree (3–10 metres in height) native to the tropics. Noni fruit and leaves have a long history of use as a meal by Pacific Islanders, as well as people in Southern and Southeast Asia. While the fruit is edible, it has been compared to the taste of rotten cheese by some. Despite this, the fruit is consumed commonly on Rarotonga, and the Burmese cook it in curries. Australian Aborigines used noni fruit from May to August, during the Northern Territory's cool-dry season. Noni leaves were eaten raw or fried in Java and Thailand. In Tahiti, fish were wrapped in leaves before baking to lend an appetising flavour to the cooked fish (West et al., 2018).

2.1.6.2 Tomatoes

On a global scale, tomatoes are a key food crop, accounting for the second biggest vegetable output and consumption in developed countries. Tomatoes and their derivatives are a rich source of carotenoids, providing roughly 80% of the daily need for lycopene, ascorbic acid, flavonoids, a-tocopherol, and potassium in the western diet. Numerous epidemiological studies have established the favourable effect of tomato consumption on the prevention of chronic diseases such as cancer and cardiovascular disease. Additionally, tomatoes contain a variety of additional compounds, such as vitamin C and phenolics, that should be considered for their synergistic effects on human disease prevention (Erba et al., 2013).

2.1.6.3 Benefits of Using Bioactivator

Bioactivator is a naturally produced microorganism containing organic compost. It enhances and promotes the microorganisms that are already present, resulting in the waste decomposing rapidly. This is accomplished by avoiding odours from being generated. Bioactivator is an all-natural product that is free of dangerous and toxic ingredients, making it eco-friendly. It is made up of naturally existing microorganisms that can encourage bacteria, hence speeding up the breakdown process. The bioactivator contains cellulose-degrading microorganisms, which are microscopic creatures that live on cellulose. Agricultural waste cellulose is employed as an energy source for the bioactivator's cellulolytic microorganism. This means that the cellulose found in plant tissues degrades into simple sugars that plants quickly absorb. The bioactivator is applied to fresh rice straw or other field waste as an inoculant. Composting has been demonstrated to be accelerated by up to one month using this inoculant. Composting organic matter increases soil organic matter, which helps maintain soil fertility while reducing the need for artificial fertilisers. It has the advantage of being incredibly adaptable and may be utilised on nearly any farm. The second advantage of employing bioactivator is that it is environmentally friendly. The bioactivator can be in the form of a liquid, a powder (bulk or water-soluble bags), a tablet or capsule, a pellet, or a slow-release tiny bar (Sutrisno et al., 2020).

There are numerous ways to use liquid organic fertiliser, one of which is by the use of a natural bioactivator obtained from plentiful noni fruit and tomato waste. Bioactivators are a group of chemicals that facilitate the breakdown of hydrocarbons by bacteria. Numerous studies demonstrate that a bioactivator generated from anaerobically fermented cow urine has a larger influence on the growth and production of elephant grass biomass than other fertilisers (Semaun et al., 2018). EM4 has previously been demonstrated to be an effective bioactivator in the synthesis of liquid organic fertiliser using milkfish waste and extra vegetable waste as input materials (Widyastuti & Lovakusuma, 2018).

The rumen contents, in the form of grass that has not been entirely fermented and digested by the cattle, are one of the slaughterhouse wastes. Additionally, cattle rumen contains nutrients that microorganisms utilise for energy. Due to the presence of various microorganisms in the rumen contents, the rumen also serves as a bioactivator, promoting the maturation of organic compost. Organic farming requires a broad population of microorganisms in the rumen. Despite their nutritious potential, the rumen contents of slaughtered ruminants such as cattle and goats are often thrown away. When utilised in the manufacture of liquid and solid organic fertilisers, as well as a bioactivator in the manufacture of goat manure fertiliser, the waste is highly beneficial (Pancapalaga et al., 2021). Nutrients content improvement in liquid organic fertilizer with presence of bioactivator are shown in table 2.1.

Table 2.1 Nutrients Content Improvement in Liquid Organic Fertilizer with Presence of Bioactivator

Source: (Semaun et al., 2018)

Bioactivator	**Nitrogen (%)**	**Phosphorus (%)**	**Potassium (%)**	**References**
Noni Fruits	1.85	2.30	2.50	(Semaun et al., 2018)
Tomatoes	1.65	2.18	2.83	(Semaun et al., 2018)

2.2 Oil Palm Fiber

Oil palms are two species within the Aceraceae, or palm family (*Elaeis guineensis*). Mature trees have a single stem and can grow to be up to 20 metres tall. The leaves are pinnate and reach a maximum length of three to five metres. Each flower is quite small, having three sepals and three petals, and grows in dense clusters. In contrast to the coconut palm, the oil palm does not produce offshoots; seed is sown to propagate the plant. The fruit matures in 5–6 months from pollination to maturity; it is composed of an oily, fleshy outer layer (the pericarp) and a single oil-rich seed (kernel). Palm oil is a product with an exponentially growing global market that contributes significantly to economic growth. Increased demand for palm oil in the form of vegetable oils motivates governments to invest in oil palm plantation development. As a result, they may increase palm oil mill effluents (Dungani et al., 2018).

Despite this tremendous output, oil represents a relatively modest part of the total biomass produced in the plantation. The remainder is composed entirely of lignocellulosic material in the form of oil palm fronds (OPF), oil palm trunks (OPT), empty fruit bunches (EFB), pressed fruit fibre (PFF), pruning oil palm frond (POPF), and oil palm ash (OPA) (Dungani et al., 2018). Surprisingly, all wastes are categorised as organic, or naturally degradable, wastes. However, because these wastes are generated in vast quantities, they have the potential to contaminate the surrounding environment. The biomass wastes from oil palms in the field and at oil palm mills are depicted in Figure 2.9. However, Sulaim (2013) reports that there is a surplus of raw materials accessible from the palm tree, which consists of around 90% biomass wastes and 10% oil. In 1998, over 90 million tonnes of oil palm fruit were produced; however, between 43 and 45 percent of this total consisted of mill wastes in the form of EFB, shell, and fibre. Palm fronds and stems are currently underutilised, creating a substantial disposal issue.

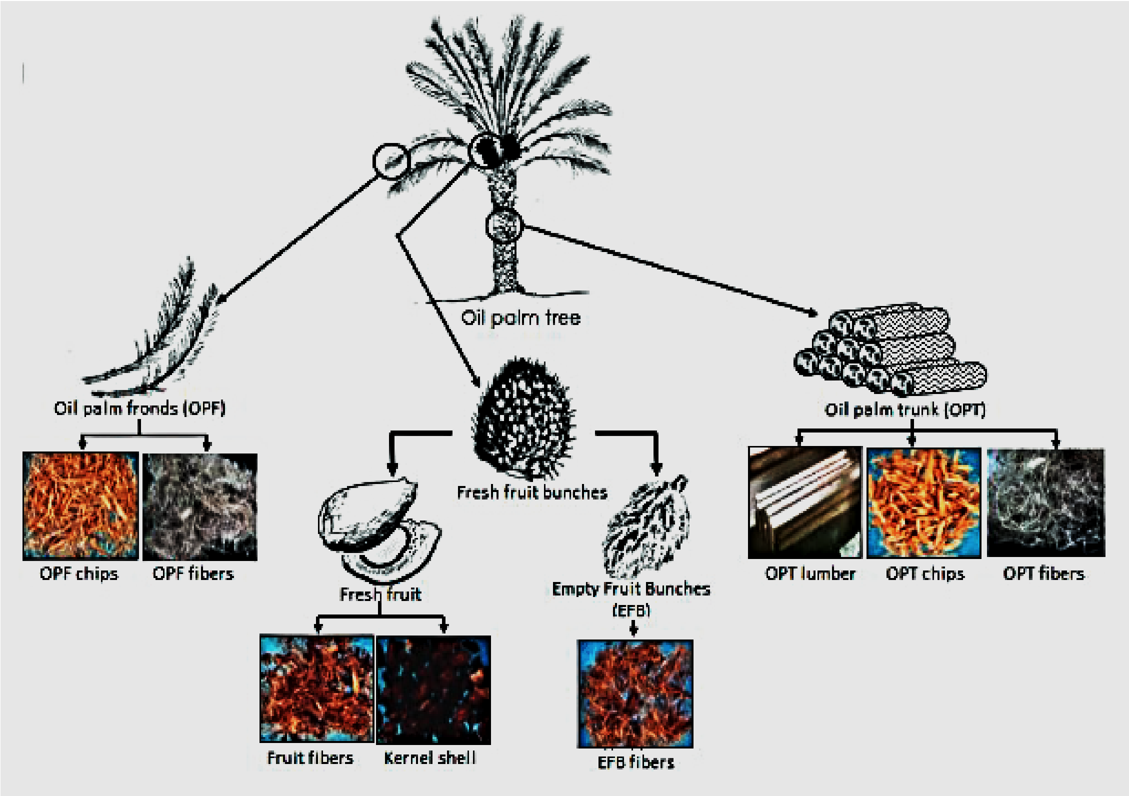

Figure 2.6 Various types of oil palm waste and derivatives

Source: Ramlee et al. (2021)

2.2.1 Oil Palm Trunk Fiber

Biomass waste from oil palm trunks is acquired after replanting, which occurs when trees reach an economically feasible age. Biomass waste from oil palm trunks is acquired after replanting, which occurs when trees reach an economically feasible age. OPT has been used to make lumber, pulp and paper, reconstituted sheets, and bio-composites. Additionally, OPT has been utilised as a cellulosic raw material in the production of panel goods including as particleboard, medium density fiberboard, mineral-bonded particleboard, block board, and cement board (Dungani et al., 2013). Additional investigation indicated that oil palm trunks are collected during the replanting of oil palm trees. OPT can be converted into value-added products to assist enterprises with increasing income. Appropriate OPT consumption also decreases reliance on agricultural raw materials sourced from tropical forests and eliminates waste. By replanting waste materials, capital production and commodities productivity can be increased. In other words, renewable resources and goods from the OPT would meet the growing need for alternative energy sources and enable the development of a competitive second generation of biofuels (Dungani et al., 2013).

With a low yield and weight, sulphate pulp was made from palm trunk fibre. It is composed of an incredibly light material and is capable of absorbing a considerable amount of water without congealing. As a result, it may be used as a raw material substitution in the manufacture of pulp and paper. The soda anthraquinone pulping method was chosen because of its high consistency and lack of sulphur, which inhibits the release of toxins and offensive odours. It requires a relatively small amount of raw material to be lucrative, which fits with some regions' limited non-wood output — in comparison to the kraft process, which requires a significant amount of raw material to be profitable. The majority of crude palm oil mills generate their own low-pressure boilers using the energy contained in the shell and fibre, and the oil palm trunk is often permitted to degrade naturally on the plantation (Sulaim et al., 2013). This action not only disturbs the decomposition process, but also facilitates the spread of disease and insects such as rhinoceros beetles and Ganoderma that are destructive to the crop. Additionally, the majority of plantations are compelled to employ push-felling and bark shredding, which results in fires (Sulaim et al., 2013).

2.2.2 Oil Palm Frond Fiber

Oil palm fronds (OPF) are a prolific byproduct of Malaysian oil palm operations. Throughout the year, oil palm fronds are accessible when the palms are cut for oil production from new fruit bunches (Abdul et al., 2012). OPF is a mixture of carbohydrates and lignocellulose that is released at a rate of 24 million tonnes per year from oil palm mills. Oil palm fronds, which consist of leaflets and petioles, are a by-product of Malaysia's oil palm industry, and their abundance has generated substantial interest in their potential use as livestock feed (Abdul et al., 2012). Following that, John (2008) asserts that because OPF is a resource, it is abundant, easily available, and inexpensive, making it an attractive raw material for a variety of value-added commodities. OPF is currently disposed of on-site via direct decomposition and combustion, with a small quantity being composted.

OPF fibres were found to include a range of different vascular bundles of differing diameters. Vascular packages with narrow walls were abundantly imbedded in parenchymatous field tissue (Syamani et al., 2015). Each package consisted of vessels, threads, phloem, and parenchymatous tissues and was wrapped in a fibrous sheath. Both the xylem and phloem tissues are clearly visible. The phloem of each bundle was segmented into two different zones. Additionally, certain vascular bundles have distinct proto-xylem components. A layer of parenchyma cells isolates the bundle's proto- and meta-xylem vessels (Khalil et al., 2021).

2.2.3 Oil Palm Empty Fruit Bunch Fiber

Oil palm empty fruit bunch fibre (OPF) is a naturally occurring fibre found in tropical climates (Mahjoub et al., 2013). Oil Palm Empty Fruit bunch (OPF) fibre is one of these abundant natural fibres in tropical climates. OPF is mostly generated from the hollow fruit bunches of oil palm trees following factory oil extraction. Nowadays, the empty oil palm fruit bunch is used for food, fertiliser, mulching, and fibre manufacturing, as the residual waste material may cause environmental issues (Shinoj et al., 2011).

Retting is used to recover oil palm fibre (OPF) from EFB. Mechanical retting (hammering), chemical retting (boiling with chemicals), steam/vapor/dew retting, and water/microbial retting are all accessible. Water retting is the most common of these processes. According to Mahjoub et al. (2013), one of the key issues with natural fibre is the hydrophilic nature of cellulose, which affects the weak interface bonding with the hydrophobic polymer utilised as a matrix. As a result, chemical surface modification techniques for natural fibres, such as alkaline treatment, acid treatment, and coupling agents, have been extensively documented in the literature to address this issue. Numerous scientific investigations and studies on the mechanical and physical properties of OPF composites have lately been published.

2.2.4 Nutrient Concentration in Biomass Components of Oil Palm

Oil palm is the most abundant oil crop in the planet. By supplying appropriate mineral nutrition, greater yield and quality crops can be achieved. Mineral nutrition is the act of providing, absorbing, and utilising essential minerals that agricultural plants require to grow and produce properly. Nitrogen, potassium, phosphorus, and available water are often considered to be the key determinants limiting crop growth, development, and eventually economic production (Mohidin et al., 2015). Table 2.2 shows nutrient concentration of oil palm fibers from different research. Nitrogen is the most significant nutritional element in terms of plant development, physiology, and carbohydrate content. It is found in chlorophyll, amino acids, proteins, and alkaloids, as well as protoplasm. Phosphorus is the second most scarce nutrient in crop production, where it is required for the transfer and storage of energy in plants. It is a constituent of nucleic acids, nucleotides, and coenzymes' structures. Inadequate availability limits plant growth. Potassium is essential for the maintenance of osmotic balance, the movement of phloem, and photosynthesis (Mohidin et al., 2015).

Table 2.2 Nutrient Concentration of Oil Palm Fibers From Different Research
Source: (Menon et al., 2003)

Fiber	Nitrogen (%)	Phosphorus (%)	Potassium (%)	References
Oil Palm EFB	0.44	0.144	2.24	(Menon et al., 2003)
Oil Palm Frond	0.23	0.027	1.18	(Menon et al., 2003)
Oil Palm Trunk	0.56	0.054	1.62	(Menon et al., 2003)

2.3 Plant Macronutrient

Macronutrients are critical for plant development and output. Macronutrients are critical for the growth and health of plants. The three primary macronutrients are Nitrogen (N), Phosphorus (P), and Potassium (K).

2.3.1 Nitrogen (N)

Nitrogen, the most abundant nutrient in plants, is also an inhibitor of development. Nitrogen is a component of all the building elements of life, including nucleic acids, amino acids, proteins, and biochemical substances. It makes up roughly 2% of plant dry tissue. Following nitrogen uptake, nitrate is assimilated and reduced to nitrite and then to ammonium via nitrate and nitrite reductases, respectively. Ammonium is converted into organic compounds in the root or shoot via the glutamine synthetase/glutamate synthetase pathway. Due to the fact that nitrogen is essential for development, plants must be able to continuously monitor and react to the amount of nitrogen present in their environment. Apart from its nutritional importance, nitrate was recently recognised in plants as a signalling chemical (Bouguyon et al., 2012). Nitrogen is required for a wide number of biological reactions. It gives plants a dark green hue and promotes growth and regeneration of leaves, stems, and other vegetative sections. Additionally, it stimulates root growth. Nitrogen promotes rapid early development, increases fruit production, accelerates the growth of leafy vegetables, and increases the protein content of fodder crops; it also aids in the absorption and utilisation of other nutrients such as potassium and phosphorus, and regulates overall plant growth (Bloom et al., 2015).

The method and timing of nitrogen delivery are crucial throughout crop development. Throughout agriculture's history, broadcasting nitrogen was a well-known practise in Sindh, Pakistan's typical agricultural method (Leghari et al., 2016). It is still employed today due to the ease and speed with which nitrogen fertilisers can be delivered, although there is a greater waste of nitrogen and plant uptake is limited. Nitrogen application by foliar application has been phased out in favour of novel technologies such as fertigation and flooding application of nitrogenous fertiliser. Recent advancements in nitrogen application tactics have significantly reduced the likelihood of N failure and enhanced the nutrient's uptake by the plant. Prior to nitrogen addition, several key considerations must be considered. They are at the top of the list. Plant/crop varieties and their root characteristics 2. As the plant proceeds through its growth cycle, it requires nitrogen. 3. Soil physical and chemical properties 4. Soil moisture content, 5. 6. Source and type of irrigation water Rate and frequency of irrigation, as well as the method of nitrogen fertiliser formulation to be employed. In nutrient management, the method of fertiliser administration is very critical. Numerous fertiliser application techniques are highlighted here (Leghari et al., 2016).

2.3.2 Phosphorus (P)

Phosphorus is a crucial component of plant growth fertiliser. Phosphorus is a necessary mineral for plant and animal growth. Additionally, it is a significant component of agricultural fertilisers, which are often derived from a non-renewable source of phosphate rock (Imai et al., 2021). Phosphorus is one of seventeen essential elements for plant growth. No other nutrient is capable of performing the tasks of P, and an adequate amount is required for good growth and reproduction. Phosphorus is a critical nutrient, which implies that it is frequently deficient in crop productivity despite the fact that crops require relatively high amounts. Agricultural crops contain an average of 0.1 to 0.5 percent phosphorus (International Plant Nutrition Institute) (IPNI, 2019).

Phosphorus is required for a range of cellular functions, including membrane structure maintenance, biomolecule synthesis, and the synthesis of high-energy compounds. Additionally, it is involved in cell differentiation, enzyme activation and inactivation, and glucose metabolism (Razaq et al., 2017). P exists in plant tissues in two forms, according to Malhotra et al. (2018): as a free inorganic orthophosphate and as organic phosphate esters. According to its total concentration, P is partitioned into compartments within plant cells. The cytoplasm contains the metabolically active form of Pi, whereas excess P is kept in the vacuole and given to the cytoplasm when needed.

2.3.3 Potassium (K)

Potassium (K) is an essential nutrient for plant development. It is referred to be a macronutrient due to the enormous amount of K absorbed by plants throughout their existence. Numerous important enzymes, including those involved in protein synthesis, sugar transfer, nitrogen and carbon fixation, and photosynthesis, are activated by K. Potassium is more abundant in plants than any other nutrient except nitrogen. Potassium accumulates in considerable amounts in certain plants and plant tissues. For example, tobacco (Nicotiana tabacum L.) leaves can produce up to 8% potassium by dry weight and may exhibit potassium deficiency symptoms if the level falls below 3%. It is crucial in terms of yield development and quality assurance (Xu et al., 2020).

Potassium is obtained in the soil from four distinct sources. The primary source of potassium in the soil is feldspar and mica, which account for 90 to 98 percent of the total. This source of potassium is present in trace amounts in plants. The second form of potassium in soil is non-exchangeable potassium, which ranges from 1% to 10% and is associated with clay minerals with a 2: 1 ratio (Prajapati et al., 2012). The non-exchangeable potassium supply acts as a reservoir of potassium in the soil. The third type of potassium in soil is exchangeable or readily accessible potassium, which is found on cation dispense sites or in the soil solution at a concentration of 1 to 2%. The potassium in the soil solution is readily absorbed by the plant's root system and then supplemented by potassium at the exchange sites. Organic matter and the soil microbial community both contain potassium and serve as a fourth source of potassium in the soil. This soil potassium supply provides only a trace quantity of the potassium essential for plant development (Prajapati et al., 2012).

2.4 Soil Parameter

Soil is a vital component of the natural world. Almost everything will expand if the soil is sufficiently nutrient-dense, has a proper pH, and is sufficiently moist. According to Neina (2019), many people feel that soil pH is necessary simply for the chemistry and fertility of the soil. Recognizing soil functions other than nutrient provision and the soil's role as a mechanism for plant growth, however, requires a multidisciplinary investigation of the soil and its features in relation to broader ecosystem functions. This enables scientists to investigate processes at a variety of scales, from the local to the regional and global. Soil biogeochemistry is an example of a multidisciplinary approach to soil science; it is concerned with biogeochemical processes. To a degree, the functions of soil ecosystems are intrinsically tied to soil biogeochemical processes, which are the links between biological, chemical, and geological processes (Neina et al., 2019).

2.4.1 pH

Due to its influence on a range of other soil qualities and processes that affect plant development, the soil reaction (pH) may be regarded a key variable. Indeed, the activity of microorganisms, as well as the solubility and delivery of nutrients, are among the most crucial pH-dependent processes. For instance, plants have more access to the majority of micronutrients in acid soils than they have in neutral-alkaline soils, which generally favours plant development (Gentili et al., 2018). The pH of the soil has a significant impact on the biogeochemical processes that occur in the soil in the natural environment. Thus, soil is referred to as the "master soil vector" because it affects a variety of soil biological, chemical, and physical qualities and processes that influence plant development and biomass yield (Neina et al., 2019).

The pH of the soil dictates the solubility, mobility, and bioavailability of trace elements, all of which have an effect on their uptake by plants. This is mostly governed by how elements partition between solid and liquid soil phases during precipitation-dissolution events induced by pH-dependent charges in mineral and organic soil fractions.

For instance, at high pH values, negative charges are more abundant, whereas positive charges are more prevalent at low pH levels. Thus, according to Neina (2019), trace elements are typically soluble at low pH due to their rapid desorption and slow adsorption rates. At intermediate pH, the pattern of trace element adsorption changes from essentially no to nearly complete adsorption within a short pH range referred to as the pH-adsorption edge.

2.4.2 Temperature

By regulating water and nutrient absorption, as well as root growth, soil temperature indirectly affects plant growth. At constant moisture content, a reduction in temperature results in a reduction in water and nutrient uptake. Low temperatures limit the movement of nutrients from the root to the shoot and vice versa. The temperature of the soil is a characteristic of both internal heat flow and heat transfer between the soil and the atmosphere (Onwuka et al., 2016). Temperate crops require cold soil temperatures to grow, which has an effect on the amount and variety of soil microbes. Soil bacteria have a key part in the nutrient cycles of all major elements, including biomass, nitrogen, and phosphorus, which affects the soil's structure and function, hence sustaining temperate crop development (Hayat et al., 2010).

The principal source of heat in the soil is solar radiation. The soil temperature is determined by using a thermometer. Due to oscillations in radiant energy and energy transfer across the soil surface, seasonal and regular variations in soil temperature are conceivable (Onwuka et al., 2018).

2.4.3 Moisture Content

The most crucial nutrient in the soil is the moisture content. Generally, soil moisture content is influenced by the soil's physical features, such as colour, form, shape, and bulk density. Soil microbes contribute to soil consistency and are necessary for processes such as nutrient cycling, organic matter breakdown, and bioremediation. Both changes in soil microbial communities as a result of ecosystem management and global change may have a significant impact on ecosystem dynamics, and because microorganisms are extremely sensitive to changes and environmental stress as a result of their intimate relationship with their environment, interest in quantifying the impacts on the biotic and abiotic components has increased in recent years (Onwuka et al., 2018). Soil moisture has an effect on bacteria' physiological state, which can impair their ability to breakdown such substances (e.g., organic substrates). Additionally, water availability affects substrate availability and surface qualities, which might have an effect on microbial communities and behaviour in general.

2.5 Comparison of Plants

2.5.1 *Alternanthera Sissoo* (Brazil Spinach)

2.5.1.1 Background

Alternanthera sissoo (Brazilian Spinach) is indigenous to Brazil and is widely cultivated across the tropics and it is a good source of flavonoids (Tiveron, 2012). Figure 2.10 shows the *Alternanthera sissoo* (Brazilian Spinach) in this project. Manurung et al.

in 2017 discovered that the maturation age of Tabat Barito had a substantial effect on the flavonoid content. However, no studies have been conducted on the yield and chemical composition of brazil spinach at various maturity ages, as well as the effect of flavonoid extract from brazil spinach supplementation on CH_4 mitigation and in vitro degradability. Under ideal conditions, *Alternanthera sissoo* is a robust grower that spreads without becoming invasive. If you're looking for an edible groundcover, it creeps along and can quickly cover a big area. When the plant is harvested by picking the tips with a downward pulling motion, fresh leaf growth is stimulated. This keeps the groundcover compact. If it is growing as a perennial, it can be cut back to the ground each year. Cuttings planted directly into the ground may be used for propagation. The ground should be maintained moist at this time, and laying a palm frond or shade-cloth directly over the cuttings will protect them for the first two weeks.

Figure 2.7 *Alternanthera sissoo* (brazil spinach)

Source: (Kress & Basaki, 2020)

2.5.1.2 Properties

Brazilian Spinach is a low growing perennial that forms a dense mound to a height of 30cm. In ideal tropical conditions, if allowed to spread, it may develop into a creeping ground cover. It features a lush green coloration and a crinkled or 'bubbly' leaf structure. In a nutshell, it resembles a salad green, which is precisely how it is used in Brazil. It is also used in place of spinach in cooking. *Alternanthera sissoo* is frequently referred to as

Sissoo or Sissoo Spinach, although it is also known as Samba Lettuce and Poor Man's Spinach.

2.5.2 *Ficus Elastica* (Rubber Plants)

2.5.2.1 Background

Ficus elastica (rubber plant) is utilised in much the same way indoors and develops significantly larger in outdoor settings. Figure 2.11 shows the *Ficus elastica* (rubber plant) in this project. Its tapped latex was previously a key source of natural rubber (Francis, 2004). Numerous *Ficus elastica* varieties have been successfully grown indoors, including "the most common," *Ficus elastica* decora (which has shiny leather-like leaves that grow to a foot in length), *Ficus elastica* robusta (which has larger leaves than decora), *Ficus elastica* black prince or burgundy (which has near-black reddish leaves), and a variety of variegated varieties.

Figure 2.8 *Ficus elastica* (rubber plants)

2.5.2.2 Properties

Ficus elastica (rubber plant) is a common Ficus genus decorative plant. It can grow to be over 30 metres tall in its natural habitat, although indoor variants are much smaller. The rubber plant is a tiny tree with broad, shiny, and appealing leaves that can be grown indoors. When this plant grows 1 to 2 feet tall, it looks terrific as a centrepiece on a table, shelf, or windowsill; however, as it reaches 3 feet, it looks fantastic standing next to a fireplace, television area, or at door entrances (as longs as there are no cold drafts). Table 2.3 shows comparison of botanical characteristic of *alternanthera sissoo* and *ficus elastica*.

Table 2.3 Comparison of Botanical Characteristic of *Alternanthera sissoo* and *Ficus elastica*

Plant Characteristics	*Alternanthera sissoo*	*Ficus elastica*	References
Plant Type	Vegetable	Indoor plant	(Manurung et al.,2017); (Francis, 2014)
Maximum Height	30 cm	3 m	(Gardens, 2016); (Francis, 2014)
Growth Rate	4-6 weeks	7-8 weeks	(Farm, 2018); (Chandrashekara, 2007)
pH	6.0-7.5	5.5-7.0	(Mcmullan, 2020); (Kitsteiner, 2014)
Moisture	Spinach thrives on soil that is uniformly damp but not damp.	Soils that not damp. Only water if soil is dry.	(Kitsteiner, 2014)
Light	Prefers partial sun	Indirect sun	(Kitsteiner, 2014)

CHAPTER 3

METHODOLOGY

3.1 Materials

The list of materials used in this study were summarized in Table 3.1.

Table 3.1 List of Materials For Production of Liquid Organic Fertilizer

No.	Materials	Usage	Supplier
1	Oil palm empty fruit bunch fiber waste	Sample of waste	FGV Palm Industries Sdn Bhd
2	Organic fertilizer liquid natural pesticide for green leaf/ Flowers	Sample of commercial fertilizer	The rendy home decor
3	Plain soil	Sample of soil	Ramlan nursery Batu 7
4	Molasses	Ingredient	Kedai kampung perak
5	Cow urine	Ingredient	rengasonlineshop
6	Fresh noni fruit	Bioactivator	Love_Nana
7	Brazil spinach plant	Check effectiveness of liquid organic fertilizer	Ramlan nursery Batu 7
8	Rubber plant	Check effectiveness of liquid organic fertilizer	Ramlan nursery Batu 7
9	Planting pot	Planting the spinach plant	Ramlan nursery Batu 7
10	Paint pail	Fermentation	Marble rescue by stonelution
11	Digital soil analyzer	Soil analysis	Avosky Malaysia
12	Digital tds and ec meter	Tds and ec analysis	daxiong86
13	Digital moisture meter	Moisture analysis	jihuishi.my

3.1.1 Selection of Commercial Organic Liquid Fertilizer

The selection of the product organic fertilizer liquid natural pesticide for green leaf or flowers as commercial organic liquid fertilizer was because the product was cheap with the price of RM18.00. Besides, it was prepared from 100% different sources of natural ingredient, contains active enzyme, bacteria and organic acid. The organic liquid fertilizer suitable for plants in the immature, flowering and fruiting periods. It also strengthened plants, reduced abscission of flower and fruits. So, this product was suitable for the comparison with the liquid organic fertilizer in this project.

3.2 Experiment Procedures

3.2.1 Collection and Preparation of Sample

The materials used in this project were oil palm empty fruit bunch fiber (OPEFBF) waste, commercial liquid organic fertilizer, plain soil, molasses, cow urine, noni fruit, brazil spinach plant, rubber plant, paint pail, digital soil analyzer, digital total dissolve solid and electrical conductivity meter and digital moisture meter. OPEFBF waste was collected at FGV Palm Industries Sdn Bhd at Lepar hilir. The amount needed for OPEFBF waste was 5kg. Next, OPEFBF waste by drying under hot sun for 2 days had been reducing the moisture content to 10%. After that, the OPEFBF waste was divided into three formulation which were formulation A, formulation B and formulation C. Formulation A consisted of OPEFBF waste 1 kg, bioactivator 0.04 L, molasses 50 g and cattle urine 2 g. Formulation B consisted of OPEFBF waste 1 kg, bioactivator 0.04 L and molasses 50 g. Formulation C consisted of OPEFBF waste 1 kg and molasses 50 g. Each of the formulation was added 1L of water. Lastly, the materials of each formulation were fermented for 14 days in paint pail using anaerobic system.

Figure 3.1 Samples preparation

3.2.2 Experimental Procedures

Formulation A, formulation B, formulation C, commercial fertilizer, and control which was soil without any mixture is among the five categories of samples. The experiment structure is depicted in Table 3.2.

Table 3.2 Experimental Samples for *Alternanthera Sissoo* (Brazil Spinach) and *Fiscus Elastica* (Rubber Plant).

Pot	Samples	Compositions
1	Formulation A	OPEFBF waste (1kg) + noni fruit (0.04L) + molasses (50g) + cattle urine (2g)
2	Formulation B	OPEFBF waste (1kg) + noni fruit (0.04L) + molasses (50g)
3	Formulation C	OPEFBF waste (1kg) + molasses (50g)
4	Commercial Fertilizer	Natural ingredient + active enzyme + bacteria + organic acid
5	Control	No fertilizer applied

Figure 3.2 LOF formulation A, B and C

3.2.3 Stem Cuttings Method

Alternanthera Sissoo had been planted in a method known as stem cutting method. The method had been applied from fully growth *Alternanthera Sissoo* into 15 cuttings. Each cutting was planted into a pot to grow. Each pot had been labelled. The cuttings were manually sown at a depth of 1/2 to 1 inch, covering the soil and keeping it moist. Watering *Alternanthera Sissoo* two times a day had been done since it takes more water and sunlight. After 21 days of growth, the *Alternanthera Sissoo* was ready to harvest. *Fiscus Elastica* does not need this method as they had been purchased at nursery.

Figure 3.3 Stem cutting method

3.2.4 Monitoring Analysis

Alternanthera Sissoo required two daily watering, and the condition of the *Alternanthera Sissoo* had been assessed in terms of soil temperature, pH, and moisture content throughout this project. After two weeks fermentation of all formulations liquid organic fertilizer (LOF), the *Alternanthera Sissoo* and *Fiscus Elastica* began fertilizing. Then, both plants had been examined for number of leaves, plant height, length of leaf and width of leaf every week. All formulation of LOF had been done nitrogen, phosphorus and moisture content analysis to get the nutrient contents. The reading of total dissolve solid and electrical conductivity were taken by using digital total dissolve solid and electrical conductivity meter. The meter was immersed in the LOF without exceeding the immersion line. The reading was taken 3 times and average value had been taken.

3.3 Flowchart of Liquid Organic Fertilizer Production

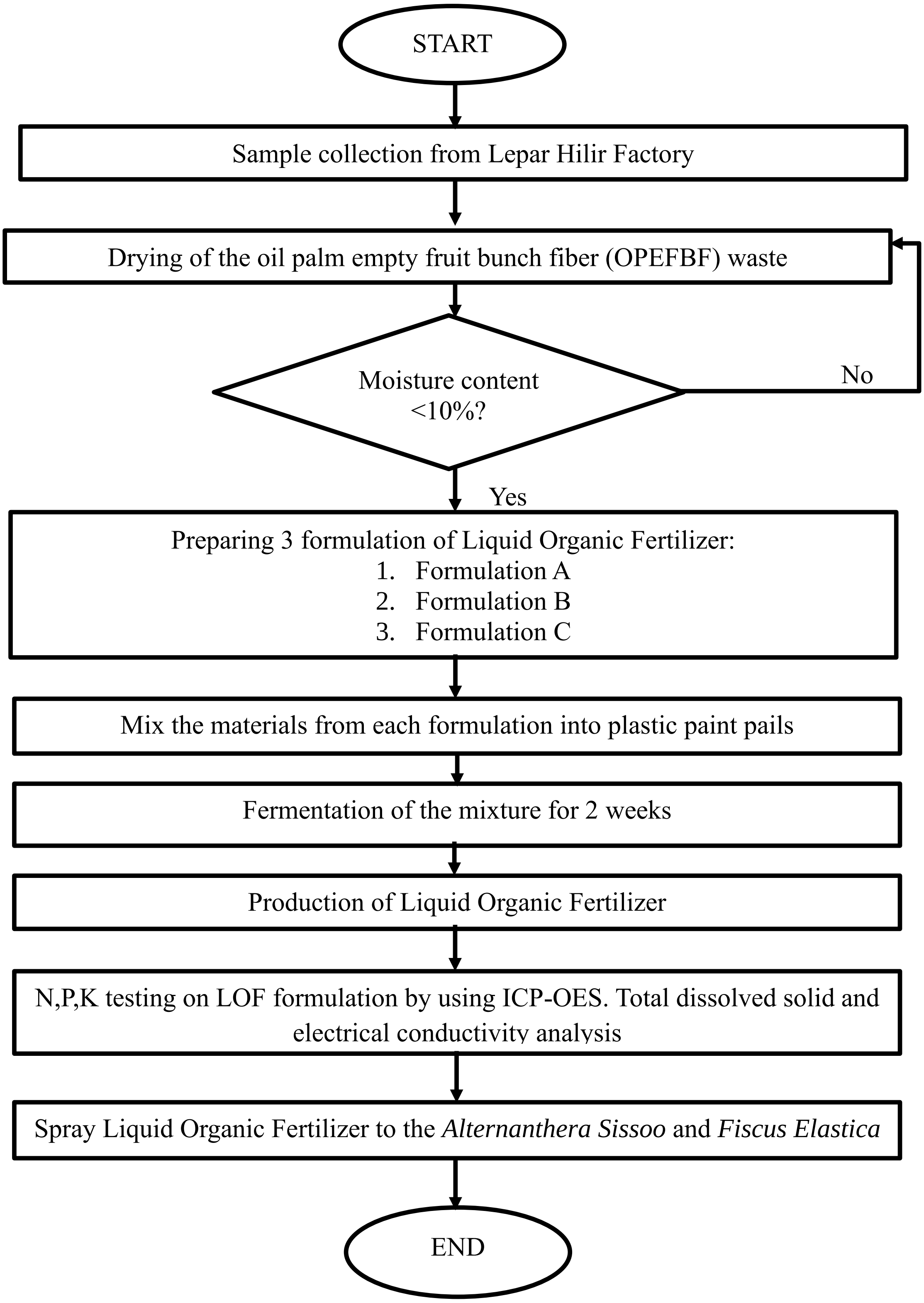

Figure 3.4 Flowchart of the liquid organic fertilizer production

This project was started with sample collection of oil palm empty fruit bunch fiber (OPEFBF) waste at FGV Palm Industries Sdn Bhd at Lepar Hilir. Permission letter had been sent to the manager of the factory, Mr. Mohamad Nor Hafizi bin Kassim. An amount of 5kg of OPEFBF waste had been taken from the factory as main material of the production of liquid organic fertilizer (LOF). The OPEFBF waste were dried under hot sun for 2 days to get moisture content below 10%. This was due to avoid excessive water content in the OPEFBF waste. If the OPEFBF had excessive water content, the concentration of LOF will decrease, thus the quality will also decrease. Three formulations of liquid organic fertilizer were label with formulation A, formulation B and Formulation C. Formulation A consists of [OPEFBF waste (1kg) + noni fruit (0.04L) + molasses (50g) + cattle urine (2g)]. Formulation B consists of [OPEFBF waste (1kg) + noni fruit (0.04L) + molasses (50g)]. Formulation C consists of [OPEFBF waste (1kg) + molasses (50g)]. 1L of water was added into all formulations as per requirement to control the formulation from becoming high concentration. Each formulation had been placed into plastic paint pails and underwent fermentation process for 2 weeks. The bacteria that had been form from all formulation had increased the nutrient content of the LOF. After the liquid organic fertilizers were produced, the LOFs had been sent for nitrogen, phosphorus and potassium (NPK) analysis by using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES). The LOFs also were undergone total dissolve solid and electrical conductivity analysis by using digital total dissolve solid and electrical conductivity meter. The meter was immersed in the LOF without exceeding the immersion line and the reading was taken three times to get the average. The LOFs were poured into plastic spray bottles using filter funnel. Finally, LOFs were sprayed to the *Alternanthera Sissoo* and *Fiscus Elastica* with amount of 2 sprays every week.

Figure 3.5 Production of liquid organic fertilizers

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Result on Moisture Content of OPEFBF Waste

The moisture content indicated the level of water content in OPEFBF waste. The OPEFBF waste was undergone drying process under the sun for 2 days. The initial weight was 8.4 kg before drying and the final weight of OPEFBF waste was 7.6 kg. The moisture content of the waste was calculated and it showed that the waste had 10.53% moisture content. The amount of moisture content cannot exceed 10.99% because to avoid of the excess of water content in the formulation. The three formulations had been added 1L of water. So, if there was excess in volume of water, the concentration of the liquid organic fertilizer (LOF) will be low thus the quality will decrease.

4.2 Result on NPK Content Inside Liquid Organic Fertilizer (LOF) using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES)

The NPK content analysis had been done by central lab UMP. Total of 13 samples consist of initial, final and commercial LOF had been sent to the central lab. The initial LOF meant that LOF that had been fermented for 2 weeks while final meant that LOF that had been fermented for 4 weeks. It took about 2 weeks to get the results.

4.2.1 Nitrogen Content in LOF

Figure 4.1 shows that the Formulation A obtained the highest nitrogen content of 485 ppm compared to other formulations. The nitrogen content for Formulation C was 465 ppm and Formulation B was 445 ppm. The rank is Formulation A > Formulation C > Formulation B. The nitrogen content for commercial LOF was 545 ppm. Formulation A is the best formulation because it had 11.6% percentage different to the commercial LOF. Formulation A is also the most formulation that closed to commercial LOF. High content of nitrogen help plants to grow faster and this allows the soil to be used more efficiently. Nitrogen, which is formed from N_2, this role is to increase overall plant growth, as nitrogen is a component of the plant cell. Nitrogen is required for amino acid and protein synthesis. Stimulate vegetative growth (green) in the same way that a leaf does. If plants lack nitrogen, they will exhibit signs such as slow/stunted growth, yellowish green leaves, narrow leaves, short and straight leaves, and old leaves that quickly turn yellow and die (Desyane, 2012). Beneficial microorganisms in liquid organic fertilizer can help improve soil nutrient availability by nitrogen fixation and the production of plant hormones such as indole-3-acetic acid (IAA), gibberellic acid (GA), abscisic acid (ABA), 1-minocyclopropane-1-carboxylate (ACC) deaminase, salicylic acid, and siderophore. Klebsiella sp. is classed as a diazotroph or nitrogen-fixer based on its features and function as a plant growth promoting rhizobacteria (PGPR). It has been primarily employed for the manufacturing of liquid organic fertiliser (Nhu et al., 2018).

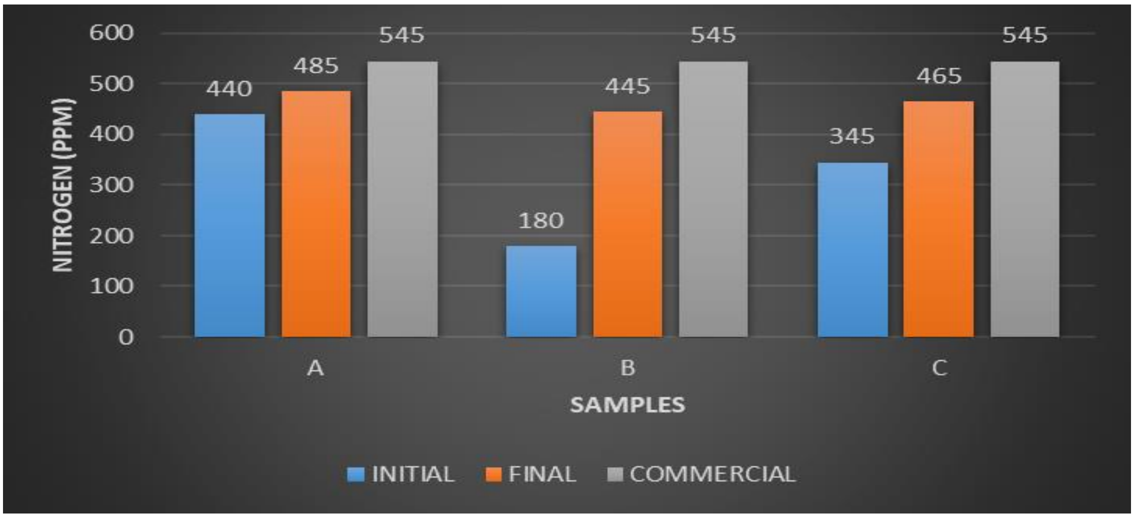

Figure 4.1 Nitrogen content in LOF

4.2.2 Phosphorus Content in LOF

Phosphorus content as shown in the figure 4.2 indicates that Formulation A contains the highest phosphorus content with 95.12 ppm compared to other formulations. The phosphorus content for Formulation C was 88.54 ppm and Formulation B was 70.74 ppm. The rank is Formulation A > Formulation C > Formulation B. The phosphorus content for commercial LOF was 100.3 ppm. Formulation A is the best formulation because it had 5.3% percentage different to the commercial LOF. Formulation A is also the most formulation that closed to commercial LOF. High content of phosphorus had assists with the growth of roots for the plants. Phosphorus, produced from P_2O_5, has several functions in the plant, including transporting energy metabolism, stimulating flowering and fruiting, stimulating root growth, increasing seed formation, and stimulating cell division and tissue expansion. Elemental phosphorus-deficient plants will exhibit symptoms of fruit/seed formation as well as stunted, decreased, or reddish purple leaves (Desyane, 2012). Phosphorus is required for proper root formation and aids in the plant's drought resistance. Phosphorus is also necessary for plant growth and development, including seed and fruit ripening (Yara, 2018).

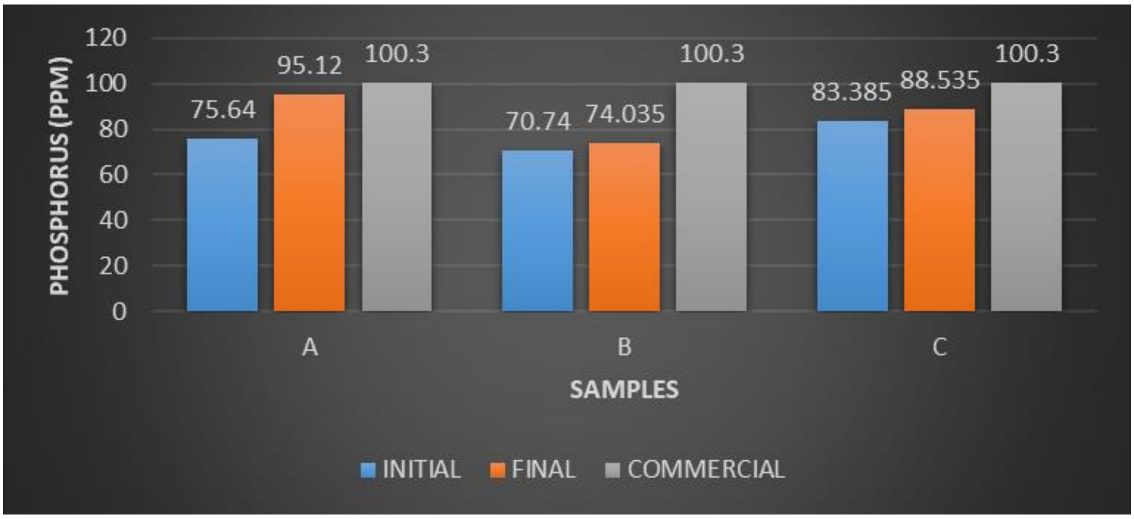

Figure 4.2 Phosphorus content in LOF

4.2.3 Potassium Content in LOF

Figure 4. shows that potassium content in Formulation A was the highest with 1007.2 ppm compared to other formulations. The potassium content for Formulation C was 990.3 ppm and Formulation B was 927.6 ppm. The rank is Formulation A > Formulation C > Formulation B. The potassium content for commercial LOF was 1012 ppm. Formulation A is the best formulation because it had 0.5% percentage different to the commercial LOF. Formulation A is also the most formulation that closed to commercial LOF. High amount of potassium content had led to the strengthens plants' stems and also fights off disease. Potassium is generated from K_2O and plays a role in photosynthesis, assimilation transport, enzymes, and minerals, including water. Increase

disease resistance in plants. When plants lack potassium, their stems and leaves become limp or fall, their dark green leaves turn bluish green, their tips yellow and dry, and brown patches emerge on the leaves (Desyane, 2012). Potassium is a critical biocatalyst in the synthesis and disassembly of carbohydrates, particularly in the conversion of proteins and amino acids. In the presence of bacteria, microorganisms use potassium as a biocatalyst, and their activity has a significant effect on the increase in potassium (Lesik et al., 2019).

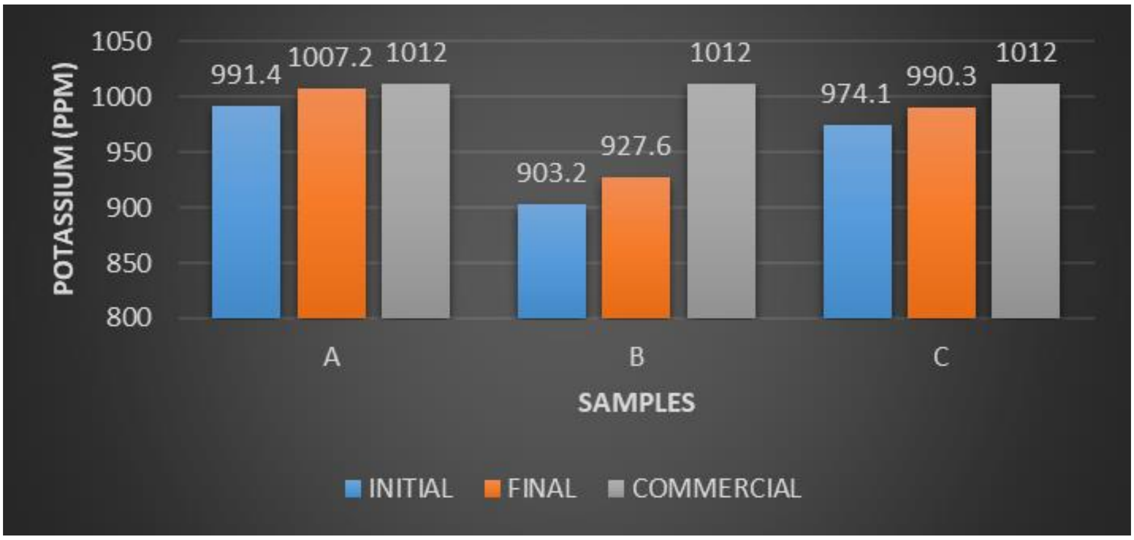

Figure 4.3 Potassium content in LOF

4.3 Result on Total Dissolve Solids in LOF

Total dissolved solids represent the total concentration of dissolved substances in liquid organic fertilizer. Figure 4.4 shows Formulation A was the lowest with 502 ppm compared to other formulations. The total dissolved solids for Formulation C was 673 ppm and Formulation B was 862 ppm. The rank is Formulation A < Formulation C < Formulation B. The total dissolved solids for commercial LOF was 400 ppm. Formulation A is the best formulation because it had 13.7% percentage different to the commercial LOF. Formulation A is also the most formulation that closed to commercial LOF. In liquid organic fertilizer, the total dissolved solids (TDS) are an effective predictor of salinity because they describe the inorganic salts and small amounts of organic materials that are present in the liquid in question (Lech et al., 2016). The total dissolved solids (TDS) concentration in water describes the presence of inorganic salts and trace amounts of organic materials in the water. TDS levels between 500 ppm and

1,000 ppm are considered to be good for health reasons. There are four types of TDS: type I is freshwater with TDS less than 1,000 ppm; type II is brackish water with TDS between 1,000 and 10,000 ppm; type III is saline water with TDS between 10,000 and 100,000 ppm; and type IV is brine water with TDS greater than 100,000 ppm (Rusydi, 2018). High in TDS affecting the plant by the root systems of the plants will eventually have trouble taking up many of the nutrients.

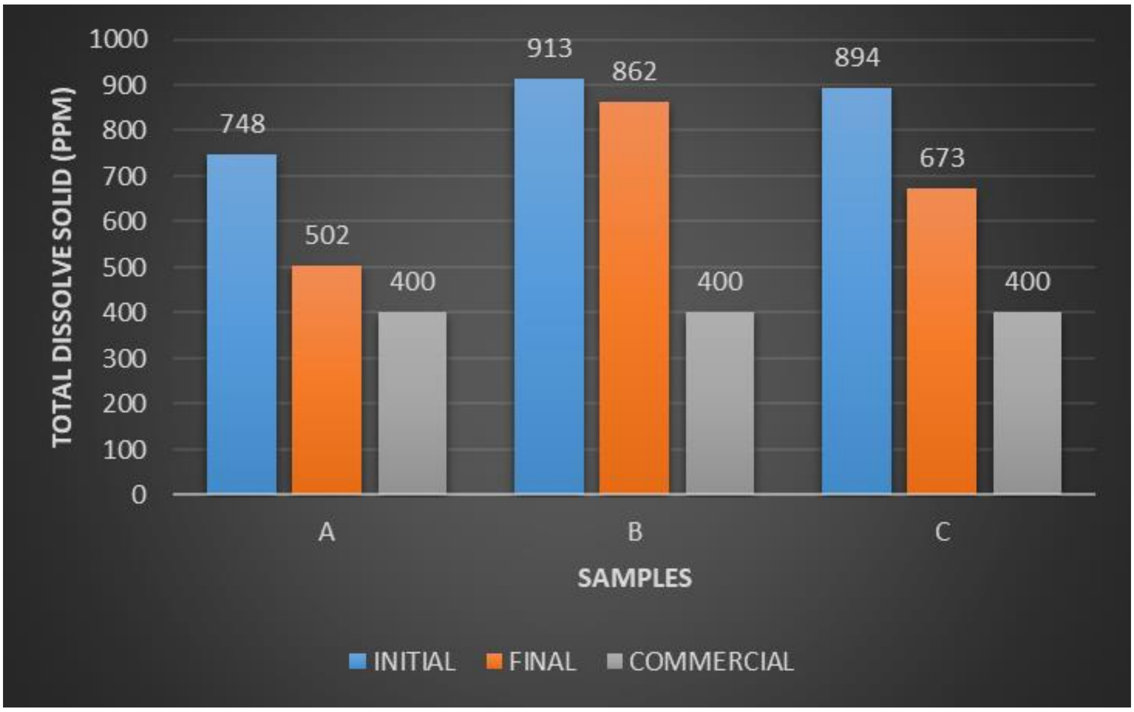

Figure 4.4 Total dissolve solids in LOF

4.4 Result on Electrical Conductivity in LOF

Electrical conductivity is a measure of the number of salts in liquid organic fertilizer. Figure 4.4 shows Formulation A was the lowest with 8.14 dS/m compared to other formulations. The electrical conductivity for Formulation B was 8.57 dS/m and Formulation C was 9.17 dS/m. The rank is Formulation A < Formulation B < Formulation C. The electrical conductivity for commercial LOF was 5.25 dS/m. Formulation A is the best formulation because it had 43.2% percentage different to the commercial LOF. Formulation A is also the most formulation that closed to commercial LOF. Excess salts hinder plant growth by affecting the soil-water balance. The electrical conductivity (EC) of a liquid is a measure of its ability to conduct an electric charge. Its capability is dependent on the amounts of dissolved ions, the ionic strength, and the temperature at which measurements are taken (Kumar et al., 2015). Materials in EC can be derived from nature, such as geological conditions and seawater, or from human activities, such as home and industrial waste, as well as agriculture (Carreira. 2014). Hence, EC is divided into 6 types: type I is non-saline, if EC less than 700 dS/m; type II is slightly saline, if EC rely between 700 and 2,000 dS/m; type III is moderately saline, if EC higher than 2,000 and less than 10,000 dS/m; type IV is highly saline with EC value from 10,000 till 25,000 dS/m; type V is very highly saline, if EC value between 25,000 and 45,000 dS/m; and type IV is brine water with EC more than 45,000 dS/m (Rusydi, 2018).

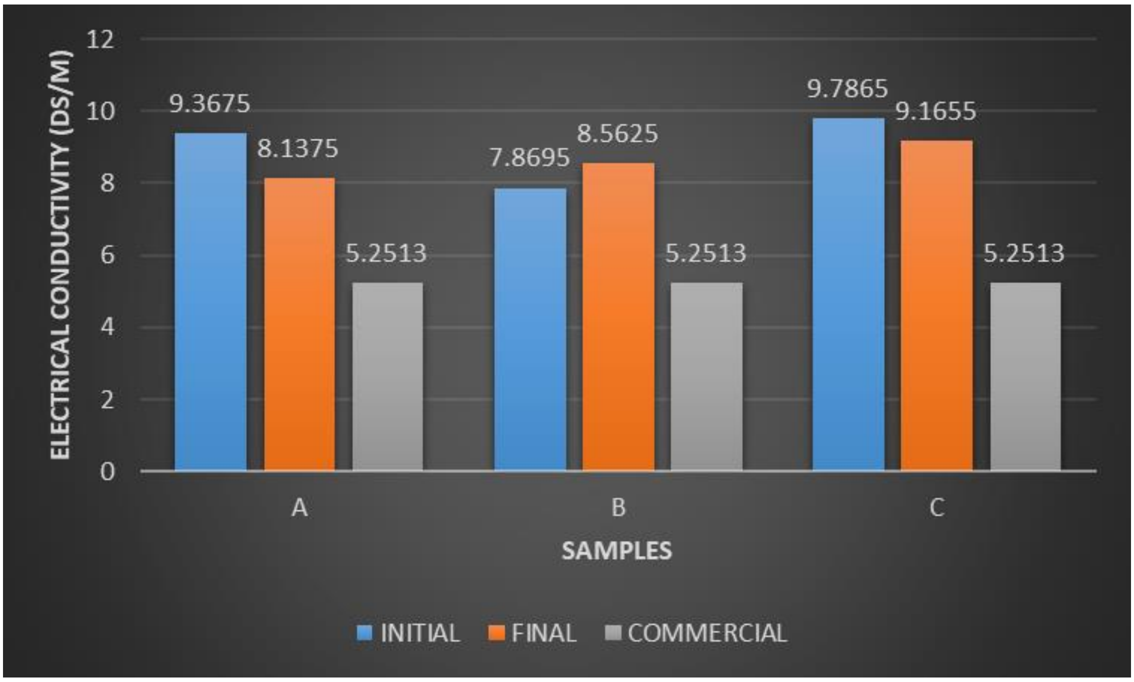

Figure 4.5 Electrical conductivity in LOF

CHAPTER 5

CONCLUSION

5.1 Conclusion

In conclusion, the objective had been achieved which were to determine the best formulation of liquid organic fertilizer from oil palm empty fruit bunch fiber (OPEFBF) waste. This project had proven that liquid organic fertilizer (LOF) was effective in enhancing the growth of *Alternanthera Sissoo* and *Fiscus Elastica*. The main ingredient of this project was oil palm empty fruit bunch fiber (OPEFBF) waste had been collected from FGV Palm Industries Sdn. Bhd. Fermentation process had been used in this project for two weeks after the three formulations of LOF had been done. All formulations and commercial LOF had been sent to central lab for nitrogen, phosphorus and potassium (NPK) analysis. NPK content in the LOF showed some great result. It showed that commercial LOF had the highest NPK content than the three formulations LOF. Among the three formulations, formulation A had been identified to be the highest NPK content. The overall ranking of the LOF were showed that commercial fertilizer at the first place, formulation A in second, formulation C in third and formulation B in fourth. Formulation A on the other hand was almost on par with the commercial LOF as it was just slightly below commercial LOF. High content of nitrogen help plants to grow faster and this allows the soil to be used more efficiently. High content of phosphorus had assists with the growth of roots for the plants. High amount of potassium content had led to the strengthens plants' stems and also fights off disease. The total dissolve solid and electrical conductivity analysis had also been done for all formulation and commercial LOF. Results showed that total dissolve solid and electrical conductivity for commercial LOF had the lowest value. This showed that the salt content in the commercial LOF was low and thus it had help both plants to absorb nutrient without having any difficulty and help plant growth. In short, formulation A was identified to be the best formulation of liquid organic fertilizer from oil palm empty fruit bunch fiber (OPEFBF) waste.

5.2 Recommendation

As a recommendation, the moisture content of oil palm empty fruit bunch fiber (OPEBFB) waste can be removed more effectively by using oven to get the exact amount of moisture. Drying the waste under a hot sun is time consuming and the exact amount moisture content is less accurate. Using oven as the best alternative to decrease the moisture content will make the waste get the exact value of moisture content needed. The oven can be set the amount of heat needed to achieve exact moisture content and it is less time consuming. Furthermore, the amount of 1 kg OPEFBF waste in the formulation should decrease to 300g. It is because 1kg of waste is too much and it will not fully soak in the mixture of formulations. 300 g of the waste will fully soak in the mixture formulation and will be fit into 2.5L paint pail. Besides, mixtures of all formulations of liquid organic fertilizer (LOF) must be done by using rubber hand glove instead of wooden spatula to ensure all ingredients mix well. The shredded OPEFBF waste was a bit hard after drying, so it is easy to use rubber hand glove and less effort will be use. Moreover, the initial nitrogen, phosphorus and potassium (NPK) values for all formulations should be taken immediately after production of LOFs had been done. This will show the original NPK values before the bacteria inside all formulations make reaction and thus increases the NPK values. After 2 weeks of fermentation process the final NPK values should be taken. In addition, total dissolved solid and electrical conductivity meter should be purchase early because it is from China and take about 3 weeks to arrive in Malaysia. The analysis for total dissolve solid and electrical conductivity was delayed from the planned time. Finally, the spraying of the LOF for some bottles do not release the same pressure, so the volume of LOF received by the *Alternanthera Sissoo* and *Fiscus Elastica* were not same. The nozzle of the spray bottles should be adjusted to make sure it released the same pressure and it can be tested using tap water first before pouring LOFs into the bottles.

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APPENDICES

APPENDIX A

COST AND BUDGET ANALYSIS

No.	Materials	Details	Price per Unit (RM)	Unit	Total (RM)
1	Organic fertilizer liquid	Volume: 1L	18.00	1	18.00
2	Plain soil	Mass: 1kg	1.00	2	2.00
3	Molasses	Volume: 1L	6.00	2	12.00
4	Cow urine	Volume: 90mL	1.90	1	1.90
5	Fresh noni fruit		0.90	10	9.00
6	Brazil spinach plant		10.00	2	20.00
7	Rubber plant		19.00	5	95.00
8	Planting pot		1.00	15	15.00
9	Paint pail	Volume: 2.5L	5.90	6	35.4
10	Digital soil analyzer		6.90	1	6.90
11	Digital tds and ec meter		15.99	1	15.99
12	Digital moisture meter		22.01	1	22.01
				TOTAL	RM 253.20

APPENDIX B

RESULT OF NPK CONTENT FROM CENTRAL LAB

A. THREE FORMULATION OF LIQUID ORGANIC FERTILIZER

BIOTROPIC/F /007

اونيۏرسيتي مليسيا ڤهڠ
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Gambang, Kuantan, Pahang Darul Makmur.
Tel : 09-5493351 Fax : 09-5493353

CERTIFICATE OF ANALYSIS (COA)

To / Attn	Dr. Nadzirah Mokhtar / Muhamad Wafi Bin Ahmad Musrab		
Address	UMP		
Tel No	017-4743253	No of sample	12
Sample Lab No	2018/463	Test Report No	TR/2021/431

Date of sample received : 11-11-2021
Date reported : 10-12-2021

RESULT:

Parameter : Total Phosphorus (as P)

No	Sample markingSample name	Result	Unit	Test Method
1.	A1	63.26	ppm	In-house Method based onAPHA 3210
2.	AA1	88.02	ppm	In-house Method based onAPHA 3210
3.	A2	90.24	ppm	In-house Method based onAPHA 3210
4.	AA2	100.0	ppm	In-house Method based onAPHA 3210
5.	B1	31.68	ppm	In-house Method based onAPHA 3210
6.	BB1	109.8	ppm	In-house Method based onAPHA 3210
7.	B2	39.57	ppm	In-house Method based onAPHA 3210
8.	BB2	108.5	ppm	In-house Method based onAPHA 3210
9.	C1	36.97	ppm	In-house Method based onAPHA 3210
10.	CC1	129.8	ppm	In-house Method based onAPHA 3210
11.	C2	69.97	ppm	In-house Method based onAPHA 3210
12.	CC2	107.1	ppm	In-house Method based onAPHA 3210

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Parameter : **Total Potassium (as K)**

No	Sample markingSample name	Result	Unit	Test Method
1.	A1	570.8	ppm	In-house Method based onAPHA 3210
2.	AA1	1,412	ppm	In-house Method based onAPHA 3210
3.	A2	672.4	ppm	In-house Method based onAPHA 3210
4.	AA2	1,342	ppm	In-house Method based onAPHA 3210
5.	B1	468.4	ppm	In-house Method based onAPHA 3210
6.	BB1	1,338	ppm	In-house Method based onAPHA 3210
7.	B2	502.2	ppm	In-house Method based onAPHA 3210
8.	BB2	1,353	ppm	In-house Method based onAPHA 3210
9.	C1	404.2	ppm	In-house Method based onAPHA 3210
10.	CC1	1,544	ppm	In-house Method based onAPHA 3210
11.	C2	690.6	ppm	In-house Method based onAPHA 3210
12.	CC2	1,290	ppm	In-house Method based onAPHA 3210

Parameter : **Total Nitrogen (N)**

No	Sample markingSample name	Result	Unit	Test Method
1.	A1	430	ppm	In-house Method based onAPHA 3210
2.	AA1	450	ppm	In-house Method based onAPHA 3210
3.	A2	460	ppm	In-house Method based onAPHA 3210
4.	AA2	510	ppm	In-house Method based onAPHA 3210
5.	B1	130	ppm	In-house Method based onAPHA 3210
6.	BB1	230	ppm	In-house Method based onAPHA 3210
7.	B2	430	ppm	In-house Method based onAPHA 3210
8.	BB2	460	ppm	In-house Method based onAPHA 3210
9.	C1	220	ppm	In-house Method based onAPHA 3210
10.	CC1	470	ppm	In-house Method based onAPHA 3210
11.	C2	160	ppm	In-house Method based onAPHA 3210
12.	CC2	420	ppm	In-house Method based onAPHA 3210

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AIMI ILMAR BIN RAMLI
SCIENCE OFFICER

B. COMMERCIAL LIQUID ORGANIC FERTILIZER

BIOTROPIC/F /007

اونيۏرسيتي مليسيا ڤهڠ
UNIVERSITI MALAYSIA PAHANG

CENTRE FOR RESEARCH IN ADVANCED TROPICAL BIOSCIENCE
(BIOTROPIC CENTRE)
Universiti Malaysia Pahang, Lebuhraya Tun Razak 26300
Gambang, Kuantan, Pahang Darul Makmur.
Tel : 09-5493351 Fax : 09-5493353

CERTIFICATE OF ANALYSIS (COA)

To / Attn	Dr. Nadzirah Mokhtar / Muhamad Wafi Bin Ahmad Musrab		
Address	UMP		
Tel No	017-4743253	No of sample	12
Sample Lab No	2018/463	Test Report No	TR/2021/431b

Date of sample received : 11-11-2022
Date reported : 10-12-2022

RESULT:

Sample marking : 2018/463
Sample name : COM

No	Parameter	Result	Unit	Test Method
1.	Total Phosphorus (as P)	100.3	ppm	In-house Method based onAPHA 3210
2.	Total Potassium (as K)	1012	ppm	In-house Method based onAPHA 3210
3.	Total Nitrogen (as N)	545	ppm	In-house Method based onAPHA 3210

Biotropic Centre will ensure the information as confidential and impartial and use reasonable efforts to protect the confidentiality of such information.
The certificate shall not be reproduced except in full without the written approval of the laboratory. The above analysis is based on the sample submitted by the customer.

....
AIMI ILMAR BIN KAMLI
SCIENCE OFFICER

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APPENDIX C

MOISTURE CONTENT FORMULAR

$$Moisture\ content = \frac{(8.4 - 7.6)kg}{7.6} x100 = 10.53\% \quad 5.1$$

APPENDIX D

THREE FORMULATION LIQUID ORGANIC FERTILIZERS

APPENDIX E

PROJECT TIMELINE FOR SENIOR DESIGN PROJECT 1

Activities	Weeks													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Group member selection	■													
Title briefing from supervisor	■	■												
Discussion on the project and task distribution	■	■	■	■	■	■								
Materials survey		■	■	■	■	■	■							
Procedure generation			■	■	■	■	■	■						
Procedure finalise							■	■						
Materials estimation							■	■	■					
First draft proposal report preparation							■	■	■	■	■	■		
First draft proposal report submission											■	■		
Slides presentation preparation											■	■		
Video Presentation generation											■	■		
Video presentation submission												■	■	
SDP 1 presentation													■	
Finalise proposal report													■	■
Final proposal report submission														■
Completion of SDP 1														■

APPENDIX F

PROJECT TIMELINE FOR SENIOR DESIGN PROJECT 2

Activities	Weeks													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Materials purchasing	■													
Collection fiber waste from factory	■	■												
Mix all the mixture into plastic paint pail		■												
Fermentation of the mixture		■	■											
Spinach plant preparation			■											
Spray the LOF to brazil spinach and rubber plant			■	■										
Parameter obervation at brazil spinach and rubber plant				■	■	■	■	■	■	■	■	■		
Record parameter data of brazil spinach and rubber plant					■	■	■	■	■	■	■	■		
Thesis report preparation					■	■	■	■	■	■	■	■		
Poster presentation preparation											■	■	■	
SDP 2 Presentation													■	■
Finalise thesis report													■	■
Final thesis report submission														■