EFFECTIVENESS OF USING LIQUID ORGANIC FERTILIZER FROM OIL PALM EMPTY FRUIT BUNCH FIBER WASTE ON PLANTS GROWTH

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ABSTRAK

Baja organik cecair telah dicipta untuk mengurangkan pergantungan tanaman ladang terhadap baja bukan organik. Ia berasaskan serat tandan buah kelapa sawit (OPEFBF), hasil sampingan pemprosesan kilang kelapa sawit yang digunakan sebagai baja organik. Kajian ini bertujuan untuk mencari formulasi optimum baja organik cecair daripada sisa gentian tandan kosong kelapa sawit dan menilai keberkesanannya terhadap pembangunan tumbuhan dan parameter tanah. Langkah pertama termasuk mengeringkan gentian dan menukarnya kepada baja organik cair. Tiga formulasi baja organik cecair dengan jumlah substrat yang berbeza telah dicipta (serat tandan buah sawit, molase, urea dan bio-activator). Langkah kedua termasuk membaja Bayam Sissoo (Alternanthera Sissoo) dan Tumbuhan Getah (Ficus Elastica) menggunakan baja organik cecair. Eksperimen ini menggunakan Reka Bentuk Rawak Lengkap dan terdiri daripada lima rawatan: Formulasi A (sisa OPEFBF 1 kg + Bio-activator 0.04 L + Molasses 50 g + Urine Lembu 2 g), Formulasi B (sisa OPEFBF 1 kg + Bio-activator 0.04 L + Molasses 50 g), Formulasi C (Sisa OPEFBF 1 kg + Molasses 50 g), baja komersial (baja siap sedia), dan kawalan (tanam tanpa menambah baja). Seminggu sekali, baja organik cair disembur pada tanaman. . Data pertumbuhan seperti bilangan daun, ketinggian tumbuhan, panjang, dan lebar daun telah dikumpul. Keputusan pertumbuhan tumbuhan menunjukkan bahawa Formulasi A memberikan prestasi pertumbuhan yang paling hebat, yang setanding dengan tumbuhan yang diberi makan dengan baja komersial. Penyiasatan ini membuktikan bahawa Formulasi A mempunyai kesan menggalakkan pertumbuhan setanding dengan baja komersial. Selain itu, ia menunjukkan bahawa produk ini adalah organik dan berfungsi sebagai bekalan nutrien yang kaya untuk tumbuhan.

ABSTRACT

Liquid organic fertilizer has been created to reduce farmed plants' reliance on inorganic fertilizers. It is based on oil palm fruit bunch fibre (OPEFBF), a by-product of palm oil mill processing used as an organic fertilizer. This study aims to find the optimal formulation of liquid organic fertilizer from oil palm empty fruit bunch fibre waste and assess its efficacy on plant development and soil parameters. The first step included drying the fibre and converting it to liquid organic fertilizer. Three formulations of liquid organic fertilizers with different substrate amounts were created (oil palm fibre fruit bunch fibre, molasses, urea, and bio-activator). The second step included fertilizing the Sissoo Spinach (*Alternanthera Sissoo*) and Rubber Plant (*Ficus Elastica*) using liquid organic fertilizer. The experiment was using a Complete Randomized Design and consisted of five treatments: Formulation A (OPEFBF waste 1 kg + Bio-activator 0.04 L + Molasses 50 g + Cattle Urine 2 g), Formulation B (OPEFBF waste 1 kg + Bio-activator 0.04 L + Molasses 50 g), Formulation C (OPEFBF waste 1 kg + Molasses 50 g), commercial fertilizer (readymade fertilizer), and control (plant without adding fertilizer). Once a week, the liquid organic fertilizer was sprayed on the plants. . Data on growth such as the number of leaves, plant height, length, and width of leaf were collected. The plant growth results indicated that Formulation A provided the greatest growth performance, which was comparable to that of plants fed with commercial fertilizer. This investigation established that Formulation A has growth-promoting effects comparable to commercial fertilizer. Additionally, it demonstrates that this product is organic and serves as a rich supply of nutrients for the plant.

TABLE OF CONTENT

DECLARATION

TITLE PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

NH4	Ammonia
Ca	Calcium
C	Carbon
℃	Celsius
Mg	Magnesium
N	Nitrogen
%	Percentage
P	Phosphorus
K	Potassium
S	Sulphur
Zn	Zinc

LIST OF ABBREVIATIONS

ABA	Abscisic acid
ACC	1-minocyclopropane-1-carboxylate
CL	Compost leachate
COD	Chemical oxygen demand
CPO	Crude palm oil
CT	Compost tea
EFB	Empty fruit bunches
EM4	Effective microorganism 4
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
PFF	Pressed fruit fiber
PGPR	Plant growth promoting rhizobacteria
PKM	Palm kernel meal
PKS	Palm kernel shell
POFF	Pruning oil palm frond
POME	Palm oil mill effluent
TDM	Total dry matter
WEP	Waste end processing

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Project Background

Fertilization is an important management technique in agricultural output. Fertilizers are compounds that give plants essential nutrients, notably phosphorus, potassium, and nitrogen. It is also widely used to deliver essential nutrients to plants in order for them to produce more. Most agricultural plants' yields increase linearly with the amount of fertilizer absorbed. However, the apparent lack of plant-available nitrogen in organic fertilizer, induced by the slow mineralization rate, results in poorer crop yields in organic fertilizer-treated areas than in chemical fertilizer-treated fields (Riddech et al., 2019).

Fertilizers came in various forms, including inorganic, organic, and biofertilizer. The majority of organic fertilizers are made entirely of organic ingredients instead of being produced from chemical sources. Liquid organic fertilizers include necessary plant nutrients and helpful microbes that assist in the recycling of organic materials. Microorganisms play an essential role in the fermentation phase by decomposing substrates (Riddech et al., 2019). Plants more easily take liquid fertilizers since their chemicals have already been degraded.

Furthermore, the harness is more efficient than solid fertilizer since it is dissolved. A binding agent is included in liquid organic fertilizer, allowing fertilizer solutions applied to the soil's surface to be used instantly by plants (Solihin et al., 2019). Thus, the addition of organic liquid fertilizer and nitrogen, potassium, and phosphorus is predicted to improve the soil's physicochemical analysis and stimulate spinach growth.

The oil palm tree in Malaysia is an essential resource, having contributed to transforming the country's agriculture and economy. However, the presence of these oil palm trash has created a severe disposal issue (Sulaiman et al., 2013). Human activity produces waste as an inescapable by-product. Agro-industrial waste management is a serious concern in many sectors throughout the globe (Hanafi et al., 2014). Pollution is caused by the processing of industrial waste in the surrounding areas. Recycling waste is a waste treatment and resource management technique. These concepts apply equally to agro-industrial trash such as palm oil dregs and urban garbage. Madusari (2019) defines *oil palm fruit fibre* as a kind of palm oil solid waste produced by a press machine. Oil palm fruit fibre, produced like yarn and contains cellulose, hemicellulose, lignin, nitrogen, phosphorus, and micronutrients, is perfect for processing into organic liquid fertilizer. Palm oil biomass fibres are continually present in oil palm fractures throughout trimming operations, oil palm stems treated after replanting (after 25 years), and periodic processing (Dungani et al., 2018). Because oil palm fruit fibre is a natural by-product, it can be utilized as a liquid organic fertilizer.

Riddech (2019) employed sugarcane leaf waste, molasses, and distillery slop as organic substrates in a previous paper to manufacture liquid organic fertilizer. 3 Molasses and distillery slop are carbon-dense agricultural byproducts. Molasses is a dark-coloured, sweet, and syrupy by-product of sugarcane and sugar beet sugar extraction with a high vitamin and mineral concentration. Slop from distilleries includes high quantities of organic contaminants as a byproduct of the distillation process at ethanol facilities. Sugarcane leaves are produced as a byproduct of sugarcane harvesting and include organic materials (Riddech et al., 2019). Despite several studies on the impacts of liquid organic fertilizer on plants, research on the impact of utilizing a liquid fertilizer using agro-industrial waste as the substrate is still lacking.

As a result, the purpose of this research is to make liquid organic fertilizer from agro-industrial waste obtained from oil palm fibres and to test the fertilizer's efficacy in supporting plant growth.

1.2 Problem Statement

For a long time, inorganic fertilizers have been derided as harmful to human health and the environment. Furthermore, inorganic fertilizers deplete groundwater resources and threaten the environment's ecology. Heavy metals are absorbed and accumulated in plant tissues due to the continuous and consistent use of inorganic fertilizers, which harms crop nutrition and grain quality. As a result of excessive usage of inorganic fertilizers, soil, air, and water have been contaminated due to nutrient leakage, soil physical characteristics degradation, toxic chemical accumulation in bodies of water, and other factors, resulting in significant environmental problems and biodiversity loss. Consequently, agrochemicals are a significant source of pollution in developing countries, posing severe health risks to humans and livestock (Kakar et al., 2020). It is possible that long-term use of inorganic fertilizers can affect soil texture, microbes, and pH levels, leading to a reduction in production. Five researchers and practitioners are working to develop alternative fertilizers, particularly organic fertilizers, despite the negative consequences of using inorganic fertilizers. Organic fertilizers, in particular, are predicted to increase plant production while simultaneously reducing the negative consequences of using inorganic fertilizers (Madusari, 2019).

The dilemma that fertilizer buyers face is whether to purchase a fertilizer that provides a higher yield but is harmful to the environment or fertilizer that protects the environment but has a slower effect on the environment. Finally, biofertilizers may replace organic and chemical fertilizers in agricultural production. Because it does not contaminate the environment in the same way as chemical fertilizer does and has a more immediate effect than organic fertilizer, it should be prioritized above organic fertilizer. Compared to chemical fertilizer production facilities, the biofertilizer manufacturing technology is also very straightforward, with low installation costs.

A low concentration of chemical components and a nutrient content sufficient to meet the plant's nutritional requirements are typical characteristics of liquid organic fertilizers. If there is an excessive amount of fertilizer in the soil, the plants will regulate the absorption of the excess fertilizer (Hendarto et al., 2018). Compared to conventional organic fertilizers, liquid organic fertilizers include greater concentrations of organic matter and soluble nutrients. This may aid soil sustainability, plant health preservation, and plant health preservation. Furthermore, coordinating the watering and fertilization cycles may enhance the efficiency of nutrients while also lowering nutrient waste. Aside from that, some of the unique molecules contained in liquid organic fertilizers, such as six chitins, as well as humid and fulvic acids, and other biopolymers, may have the ability to act as plant bio stimulants (Ji et al., 2017).

1.3 Objectives

The objectives of this research are:

i. To determine the best formulation of liquid organic fertilizer from oil palm empty fruit bunch fiber (OPEFBF) waste.

ii. To evaluate the effectiveness of the liquid organic fertilizer from OPEFBF waste on growth *Alternanthera Sissoo* (Sissoo Spinach) and *Ficus Elastica (*Rubber Plant)

iii. To examine the impact of using liquid organic fertilizer on soil parameters.

1.4 Research Scopes

i. The experiment focused at oil palm empty fruit bunch fiber waste as a substitute liquid organic fertilizer, which will be collected at Lepar Hilir Palm Oil Industry.

ii. It contains three liquid organic fertilizer formulations. Oil palm fiber empty fruit bunch fiber waste, molasses, a bio-activator, and cattle urine are used in the formulation. The market liquid organic fertilizer and a control sample are included in this sample.

iii. The research would only evaluate *Alternanthera Sissoo* (Sissoo Spinach) and *Ficus Elastica (*Rubber Plant) growth and development in nurseries.

iv. The thesis would equate the growth and production of *Alternanthera Sissoo* (Sissoo Spinach) and *Ficus Elastica (*Rubber Plant) grown with five different treatments in terms of the following: phytomorphology characteristics of *Alternanthera Sissoo* (Sissoo Spinach) and *Ficus Elastica (*Rubber Plant) and soil parameter.

v. An automated moisture meter is used to determine the compost and soil's pH, temperature, and moisture content.

CHAPTER 2

LITERATURE REVIEW

2.1 Liquid Organic Fertilizer

Liquid organic fertilizers have seen a significant increase in recent years in modern agriculture industries. Liquid organic fertilizers are primarily used to produce high-yielding plants such as healthy green lawns and hearty plants because they contain growth-promoting macronutrients, micronutrients, fulvic, and humic acids (Akyol et al., 2013). Liquid organic fertilizer is more readily absorbed by plants and is more economical to use because it can be diluted. These fertilizers can be produced quickly and with high quality by composting the basic ingredients dissolved in water and supplemented with a variety of bio activators (Rahmad et al., 2019). The traditional market-waste organic fertilizer also owns liquid organic fertilizers. On the other hand, manufacturing or processing wastes into fertilizer can help reduce pollution and extend the life of WEP (Waste End Processing) sites, due to the decreased number of wastes dumped into the site. Additionally, waste processing provides an opportunity to reduce unemployment. A traditional market can generate daily wastes up to a volume of 100 m3, implying that the capacity for producing liquid organic fertilizers made from traditional market wastes must be enormous in order to ensure their long-term availability (Hendarto et al., 2018).

2.1.1 History and Background

Nowadays, organic agriculture is a rapidly growing technology in the Philippines, partly because it addresses waste disposal issues by converting biodegradable wastes into organic compost, thereby ensuring the availability of organic fertilizer for crop production. Additionally, organic vegetable production enables the production of high-quality vegetables at any time of year due to the absence of chemical application. It also contributes to the rehabilitation and maintenance of the fertility of our croplands that have been degraded or are at risk of degradation as a result of intensive crop production and poor soil management practices. Due to the enhancement of new organs and fibrous root development, organic fertilizers derived from animals produce a greater total biomass than vegetal-derived fertilizers. Organic fertilization, on the other hand, increased plant biomass in the same way that cow manure and compost made from municipal solid waste and pruning material did. Nonetheless, it is worth noting that in this experiment, animal manure was predigested to create a liquid fertilizer, which increased nutrient availability in comparison to direct application of cow manure (Martínez et al., 2016).

The most widely distributed liquid organic fertilizer in Indonesia is produced by commercial traders who already have a name and a well-known trademark for liquid fertilizer produced by small-scale farmer groups. Additionally, the impact of a high-quality liquid organic fertilizer varies by community. According to some crop farmers' experience, liquid organic fertilizer has a negligible effect on rice yield improvement. Among the difficulties encountered by liquid organic fertilizers are their limited availability, the content and composition of the nutrients contained in them, and their manufacturing techniques are still primitive (Munir, 2018).

2.1.2 Process in production of liquid organic fertilizer

The use of liquid waste as a liquid organic fertilizer is limited by the lack of appropriate technology for producing fertilizer with high nutritional and aesthetic values. It is believed that liquid waste fermentation technology could be used to treat liquid waste from chicken slaughterhouses. However, there are issues with the characteristics of this liquid waste, as it is quite distinct and dissimilar to other liquid wastes. These distinctions may result in variations in the fermentation process's performance (Sastro et al., 2013). Rubber wastewater that is simply dumped into the environment creates odor problems, depletes soil nutrients, and contaminates water. One strategy for addressing this is to convert rubber industry liquid waste into liquid compost fertilizer. Liquid compost fertilizer is a material derived from plants and engineered to improve the soil's physical, chemical, and biological properties. Composting is the process by which organic matter is decomposed or destroyed by a variety of organisms in a specific environment, resulting in compost with no adverse effects on the soil. Composting can be aided by using a biofertilizer as a decomposer to improve the compost's quality and speed up the decomposition process. One of the most commonly used decomposers is EM4 (Effective Microorganism 4), which is readily available and inexpensive. (Ali et al., 2019).

2.1.2.1 Fermentation

Microorganisms are working well when conditions are appropriate during the fermentation process of organic materials. The fermentation process will occur in a semi-anaerobic environment with a pH of 3-4, high salinity and sugar content, a medium water content of 30%-40%, fermentation microorganisms, and a temperature range of 30-50C (Ali et al., 2019). It has been reported that using rapeseed cake, soybean meal, or other meals as a fertilizer can increase the number and activity of microbes in the soil and thus improve the quality of the plants. Composting fermentation meal fertilizer is still a traditional method of fertilizer production in many parts of China. However, this method has several drawbacks, including a lengthy fermentation period (one to six months) and significant nitrogen loss (nearly 30%–50% during the composting process). As a result, nitrogen cannot be utilized effectively and sufficiently for plant growth, rendering the use of meal for this purpose inefficient (Wang et al., 2014).

Utilization of organic material derived from animals through the use of fishery waste may be an alternative. In this instance, the fermentation process may result in the production of liquid fertilizer. However, fishery waste cannot be used directly as liquid fertilizer because the organic matter contained in the waste, in the form of fat and protein, cannot be absorbed by the plant. Organic matter in wastewater should be broken down to simpler organic compounds so that plants can more easily absorb the nutrients contained in organic liquid fertilizer (Widyastuti et al., 2018). Liquid organic fertilizers made from agricultural residues and industrial wastes are gaining popularity in Thailand. These fertilizers are made through simple fermentation processes that utilize organic waste as a carbon source. Liquid Organic fertilizers are composed of essential plant nutrients and beneficial microorganisms that aid in the recycling of organic matter. Microorganisms play a critical role in the fermentation process by degrading substrates. At the conclusion of the fermentation process, liquid organic fertilizers contain phytohormones such as auxin and cytokinin, organic acids, and plant growth promoters (Phibunwatthanawong et al., 2019).

The example of fermentation in liquid organic fertilizer is apple fruit fermentation. Apple fruit fermentation is a rapid and simple method of producing a liquid organic fertilizer from naturally fallen fruits or those that have detached during crop thinning. Apple fruit fermentation promotes organic matter decomposition, releases minerals, biologically active substances, and secondary metabolites, and stimulates microbe growth in the soil. Thus, apple fruit fermentation may provide nutrients, regulators, and other beneficial compounds that aid in the promotion and regulation of plant growth and development. Additionally, its use can help reduce decaying fruit accumulation in an orchard environment and helps prevent 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, including cut shoots, drooping flowers, and plant cuttings, are being evaluated for their potential to enhance plant development and orchard soil quality in a similar manner (Zhang et al., 2016).

2.1.2.2 Composting

Composting is the process by which organic residues of plant and animal origin are converted into manure. Composting produces the compost, which is rich in humus and plant nutrients, as well as carbon dioxide, water, and heat. It requires oxygen to complete the composting process, referred to as aerobic composting. Composting is a controlled decomposition process that mimics the natural breakdown process. Composting is the process of converting raw organic matter into biologically stable humic substances that are suitable for a wide variety of soils and plant applications. Composting produces organic fertilizers. Organic fertilizers are made from vegetables, fruits, and animals, among other things. Organic fertilizers are critical in the agricultural sector because they benefit the soil without causing harm to the ground water or plants (Hamid et al., 2019).

Organic liquid fertilizer is a by-product of composting bio-waste. Compost liquid fertilizer may act as a bio stimulant, increasing crop yield and quality, suppressing plant pathogenic microorganisms, providing water-soluble nutrients to the plant, and enriching the soil with the microorganism. Compost liquid fertilizer is an excellent source of potassium (K), magnesium (Mg), calcium (Ca), sodium (Na), and a variety of other microelements. It contains humic acids, which regulate the absorption of micronutrients and macronutrients. The liquid fertilizer compost can be obtained as leachate (CL) or can be made by mixing the compost with a specific solution to obtain a liquid extract known as compost tea (CT). From Figure 2.1, compost solid and liquid fertilizers made from bio-waste should be marketed as an organic fertilizer (Shiun Lim et al., 2019).

Numerous microorganisms, including Biosca and Trichoderma harzianum mushrooms, are capable of composting. Biosca is a liquid decomposer that contains numerous microorganisms that aid in the breakdown or decomposition of organic waste into fertilizer. These microorganisms are nitrogen fixers that are alginolytic, cellulolytic, proteolytic, lipolytic, amino lytic, and non-symbiotic. Biosca was used in one study to convert leachate wastewater (liquid piles of organic matter) into a liquid organic fertilizer with a relatively high nutrient content for plants (Rahmad et al., 2019). Composting, at its most basic level, entails assembling a heap of wet organic matter known as green waste (leaves, food waste) and waiting for the materials to decompose into humus over a period of weeks or months. Composting in the modern era is a multi-step, closely monitored process that requires precise inputs of water, air, and carbon and nitrogen-rich materials. The process of decomposition is aided by shredding the plant matter, adding water, and regularly turning the mixture to ensure proper aeration. Worms and fungi agglomerate the material further. Bacteria that require oxygen to function (aerobic bacteria) and fungi control the chemical reaction by converting the 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 fertilizers 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 the results of liquid residues from lipopeptide production that could promote tomato growth and increase the diversity of the soil's microbial community, as well as the associated enzyme activation (Ji et al., 2017). Liquid organic fertilizers are composed of essential plant nutrients and beneficial microorganisms that aid in the recycling of organic matter. In the fermentation process, microorganisms play a critical role in the degradation of substrates. Phytohormones such as auxin and cytokinin, organic acids, and plant growth promoters are present at the end of the fermentation process in liquid organic fertilizers (Phibunwatthanawong et al., 2019).

Beneficial microorganisms in biofertilizers have the potential to improve soil nutrient availability through nitrogen fixation, phosphorus metabolism, and the provision 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 classified as a diazotroph or nitrogen-fixer based on its characteristics and function as a plant growth promoting rhizobacteria (PGPR) and has been primarily used to produce liquid organic fertilizer and bio-fertilizer (Nhu et al., 2018).

2.1.4 Production of Liquid Organic Fertilizer

Organic fertilizer is composed entirely of organic matter. It is available in several forms, including solid organic fertilizer and liquid organic fertilizer. Organic raw materials may be obtained from human-generated waste or abandoned organic waste. In Indonesia, for example, coconut husk and cane skin waste are abundant, providing a source of liquid organic fertilizer. A study found that using solid organic fertilizer made from bakery waste in combination with liquid organic fertilizer and goat droppings and coconut husk resulted in increased mustard production compared to using only solid organic fertilizer made from bakery waste. On soybean plants, application of liquid organic fertilizer derived from water hyacinth waste increased soybean yield by 21.6%

when compared to treatment without application of LOF derived from water hyacinth waste (Jajuk et al., 2017).

Agricultural waste is a by-product of agriculture that is not utilized or disposed of properly, such as vegetable waste, rotten fruit, coconut fiber, agricultural waste, fisheries waste, and household waste, all of which contribute to environmental pollution, disease transmission, and interference with environmental cleanliness. To help reduce agricultural product waste, waste can be used to fertilize the soil as organic fertilizer. According to research, the highest concentration of macro-nitrogen (N) is found in vegetable liquid waste, phosphate (P) is found in vegetable and fruit waste, and potassium (K) is found in fruit waste, while the microelement 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 (NH3) is found in liquid fertilizer mixture of vegetable and fruit waste. Rumen cattle are unutilized slaughterhouse waste, but still contain nutrients, microbes, and undigested food that can be recycled. Utilizing rumen waste to create liquid organic fertilizer is one way to recycle slaughterhouse waste. This utilization will mitigate the risk of environmental and water pollution caused by the accumulation of rumen contents in slaughterhouse waste (Lesik et al., 2019).

2.1.4.1 Sewage Sludge

Massive amounts of sewage sludge production have become a serious problem in several countries in recent years. Sewage sludge production is increasing in conjunction with wastewater discharge in developing countries, such as China, resulting in extremely serious environmental pollution. As a result, the sludge pollution problem should be addressed immediately. Sewage sludge is a type of biomass that results from wastewater treatment, its moisture content can exceed 80%, and it also contains a high amount of organic matter. As a result, it is extremely prone to rot, and the odor problem is also quite severe. With the growing production of sewage sludge, interest in the disposal method is growing. Now, sludge disposal options include landfill, incineration, and agricultural use. However, these traditional sewage sludge disposal methods are insufficient to meet the treatment need, as the sludge poses a serious risk to human health and the environment even with these methods (Sun et al., 2013).

Chemical fertilizers primarily composed of nitrogen, phosphorus, and potassium (NPK) have had a significant environmental impact over the years due to their widespread use on numerous lands throughout the world. This highlights the importance of recycling various types of biomass waste into organic fertilizers, including animal manure, sewage sludge, and food waste. Organic waste suitable for agricultural fertilizer production can be classified into three types: animal-derived organic waste (manure), compost (plant-derived organic waste and food waste), and urban waste (sewage sludge and household waste). These wastes are processed to increase their nutritional content and agricultural value, thereby contributing to a more biodiverse economy and environment (Chew et al., 2019). Due to the high nitrogen, phosphorus, and organic matter content of sewage sludge, it has potential fertilizer properties and can be used to enrich agricultural soils. Within certain limits, sewage treatment plant sludge can act as a moisture source and as a pH regulator. Along with the essential elements for plant growth, sludge may contain trace amounts of heavy metals and other pollutants (Iticescu et al., 2018).

Prior to applying sewer sludge in the natural environment, the substance must be stabilized and prepared via biological, chemical, thermal, or other means to reduce its putrefaction potential and eliminate any risk to the environment or human health. The use of sewage sludge for fertilization reduces the need for mineral fertilizers and replenishes terrestrial ecosystems with biogenic elements. Additionally, the cost of operating energy crop plantations is lower (Wierzbowska et al., 2016).

2.1.4.2 Manure

Organic manure has a few disadvantages, including a low nutrient content, a slow rate of decomposition, and nutrient compositions that vary according to the organic materials used. However, organic manure provides numerous benefits, including a balanced supply of nutrients, increased soil nutrient availability due to increased soil microbial activity, the decomposition of harmful elements, soil structure improvement and root development, and increased soil water availability. According to a study conducted on tomatoes (Lycopersicon esculentum) and corn (Zea mays) grown in acidic soil, organic manure improves crop productivity, nitrogen utilization efficiency, and soil health when compared to chemical fertilizers. The number of studies conducted in agricultural fields have concluded that combining chemical fertilizers and organic manure reduces the damage caused by chemical fertilizers and increases crop productivity. (Han et al., 2016). Organic manure has the ability to lower the pH of the soil and increase the electrical conductivity of nutrient absorption (Purbajanti et al., 2020). Liquid organic fertilizers such as poultry manure tea and compost tea have been found to contain a significant amount of nitrogen in the inorganic form of ammonia and can provide nutrients to plants almost instantly, similar to chemical fertilizers (Jigme et al., 2015).

2.1.4.3 Agro Industrial Waste

Organic agriculture aims to produce high-quality food while also respecting the environment and preserving soil fertility through resource efficiency. Organic agriculture encourages nutrient recycling to reduce the amount of nutrients imported to the farm. Organic waste application in soil is an effective method for preserving soil organic matter, improving soil fertility, and supplying nutrients to plants. Organic fertilizers are made from natural materials and are therefore more environmentally friendly than chemical fertilizers. Numerous agricultural wastes, including animal wastes, agricultural and industrial effluents, municipal wastewater, and biosolids that have been enhanced with plant nutrients. Around 15 million tonnes of municipal waste, 20 million tonnes of crop residue, and 275.5 million tonnes of animal manure are included (Buang et al., 2018). Olive pomace is one of the most significant organic agro-industrial wastes in Mediterranean countries, with a high organic matter content (approximately 90%) that can be recycled profitably via composting for use as fertilizer in agriculture. Olive pomace is a semisolid fraction obtained following the extraction of olive oil via two-phase centrifugation systems. It is produced in large quantities over a short period of time (October-November), and its improper disposal can have a detrimental environmental impact. This is because phenolic compounds and the lipid fractions have phytotoxic and antimicrobial properties. Recomposting the pre-processed olive pomace with an on-farm compost made from vegetable residues may be a viable method of recycling this waste resulting in a biofertilizer with an appropriate degree of stability and maturity. Recomposting olive pomace can result in a decrease in the C/N ratio and an increase in microbial activity when compared to the starting material (Diacono et al., 2019).

Fertilizer nutrient costs are increasing daily beyond the reach of small and marginal farmers, highlighting the negative consequences of unbalanced fertilizer use. The continued use of NPK fertilizers with a high analysis has resulted in the occurrence of sulphur and micronutrient deficiencies. Thus, conservation and efficient use of natural resources such as organics derived from agricultural wastes are necessary for achieving sustainable high yields in food and nutritional security while also maintaining environmental safety (Pal et al., 2014). When agricultural effluents are not treated, they contribute to environmental pollution. These nutrients, which are referred to as nutrient-dense wastes, can be converted into an excellent source of organic fertilizer when properly treated (Elaiyaraju et al., 2016).

2.1.4.4 Food Waste

Food waste is any food substance that is discarded or recycled after it has been consumed. Food waste is generated in households, markets, hawker centres, supermarkets, and food courts, among other places. These wastes must be eliminated in order to maintain a safe and healthy environment. These goals can be accomplished by composting waste and producing compost for field crop production. Food waste contains a significant amount of energy, making it an ideal candidate for generating energy while also stabilizing waste. Organic or bio-waste accounts for more than a third of all waste generated in households. Organic matter loss directly impoverishes land, degrades agricultural land, reduces forests, draws up accumulated carbon deposits (oil, gas), exacerbates social inequality in the countries that produce these products, and contributes to climate change, among other negative consequences (Amra Bratovcic et al., 2018).

Numerous studies have documented a variety of methods for converting food waste to fertilizer. One technique is referred to as compost free technology. Compost free technology converts chopped food waste and other green wastes into organic fertilizer using heat and enzymes. Another study established that the Berkeley and Bokashi methods can be used successfully in Malaysia to create fertilizer from food waste. This study discovered that peanut crops fertilized with Berkeley and Bokashi fertilizer have a faster growth rate, increased nodulation increment, and higher yields than crops fertilized with inorganic fertilizer (Amiruddin et al., 2020). Berkeley method is hot composting, also known as aerobic treatment of food waste. It is a biological process in which waste material is broken down by various microorganisms including bacteria and fungi into hygienic, humus-rich substances in the presence of oxygen. It has been demonstrated to be the most effective method of treating green waste and food waste. The Bokashi method is a form of fermentation referred to as anaerobic digestion. It is one of several products containing effective microorganisms. Anaerobic Bokashi is fermented in closed containers at a low temperature (Daud et al., 2016).

2.1.5 Sources That Enhances Productions of Liquid Organic Fertilizer

Organic fertilizers are one of the production costs associated with the organic farming system. Organic fertilizers typically have a low nutrient content and must be applied in large quantities to meet crop nutrient demands, which makes them ineffective and inefficient at times. As a result, liquid organic fertilizers are developed to enhance crop growth and yield. The use of locally available organic material as the liquid organic source is advantageous and practically adaptable to local farmers. Thus, it is critical to determine the nutrient content of these indigenous materials to produce a high-quality liquid organic fertilizer (Sopha et al., 2019).

2.1.5.1 Molasses

Molasses is a by-product of fermentation that can be used in the food industry in applications such as distilleries, sugar, and yeast production. These processes, however, generate a substantial amount of wastewater. Molasses wastewater is dark brown in color and contains a high concentration of naturally recalcitrant substances, such as melanoidins, and its pigment is difficult for microorganisms to degrade. Additionally, molasses' liquid waste is acidic, with a pH of 3.5 to 4.5, contains a high concentration of organic and soluble materials, and has a high biological oxygen demand (BOD) and chemical oxygen demand (COD). Due to the presence of poorly biodegradable compounds such as melanoidins, molasses wastewater treatment has become a difficult task. However, molasses wastewater is an excellent source of minerals such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulphur (S), micronutrients, and organic matter (Li et al., 2020). Agro-industry waste included distillery slop, molasses, and bio-methane wastewater. They are rich in nutrients and can be used as a substrate to produce organic fertilizers. As a result, the factories' goal is to minimize these wastes through conversion to high-value agricultural products (Riddech et al., 2019).

Molasses is produced in large quantities each year and is used in a variety of industries, including animal feed, ethanol, and fertilizers. Sugar beet molasses improves nutrient element uptake efficiency and soil biological activity when used in agriculture. Molasses has historically been used as a fertilizer and soil improver, especially on sandy soils and soils with a poor structure. Molasses provides carbohydrates and alters the carbon: nitrogen ratio in the soil, thereby affecting soil microbial ecology and reducing plant parasitic nematodes, among other beneficial effects on plant growth. Increased nitrogen, phosphorus and potassium (NPK) uptake and yields were achieved using filter mud cake and molasses. Molasses enhances soil aggregation and reduces crusting on the surface of hard-setting soils. Molasses partially sterilizes soil and increases nitrogen fixation (Pyakurel et al., 2019).

2.1.5.2 Urea

Nitrogen is the nutrient that plants require the most. Nitrogen is a critical nutrient for the growth and development of healthy plants. Farmers frequently over-fertilize sweet corn, which degrades soil fertility. Sufficient urea should be applied without jeopardizing soil fertility. Nitrogen deficiency is a more frequent constraint on sweet corn production than other elements. It is assumed that the addition of urea fertilizer containing 46% nitrogen nutrient will reduce the sweet corn plant's N nutrient deficiency (Pangaribuan et al., 2018). The most frequently used fluid nitrogen fertilizer is urea ammonium nitrate. Urea ammonium nitrate is a non-pressurized solution that has a wide range of agricultural applications. For a long time, growers have had access to a versatile liquid urea and ammonium nitrate mixture. It provides rapid and long-lasting nutrient supply to plants through a combination of three forms of nitrogen. Nitrate-nitrogen provides an immediate response, while ammonic-nitrogen provides a more sustained response and continuous nutrition via the water-soluble organic nitrogen in urea. Liquid urea is a urea solution that is diluted with water. The advantages of liquid urea include a slower rate of uptake by the plant, which aids in maintaining nitrogen levels in the soil-plant system. It is recommended to apply liquid urea during the warm periods of the growing season to rapidly correct nitrogen deficiency (Walsh et al., 2016).

2.1.6 Comparison of Natural Bio-activator

2.1.6.1 Noni Fruits

Noni is the common name for Morinda citrifolia, a small to medium-sized tree (3–10 m in height) that is found throughout the tropics. Noni fruit and leaves have a long history of being consumed as food by Pacific Islanders, as well as those in Southern and Southeast Asia. While the fruit is edible, some have compared its flavour to that of bad cheese. Despite this, Rarotongans consumed the fruit frequently, and the Burmese cooked it in curries. Australian Aborigines consumed noni fruit during the Northern Territory's cool-dry season, which runs from May to August. In Java and Thailand, noni leaves were consumed raw or cooked. Fish were wrapped in leaves in Tahiti as part of the baking process to impart an appealing flavour to the cooked fish (West et al., 2018).

2.1.6.2 Tomatoes

Tomatoes are a significant food crop on a global scale, accounting for the second highest production and consumption of vegetables in developed countries. Tomatoes, along with their derived products, are a significant source of carotenoids, accounting for approximately 80% of the daily requirement for lycopene, ascorbic acid, flavonoids, a-tocopherol, and potassium in the western diet. Numerous epidemiological studies have demonstrated tomato consumption's beneficial effect in preventing 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). From Table 2.1, it shows the different value of nitrogen, phosphorus, and potassium for noni fruits and tomatoes.

2.1.6.3 Benefits of Using Bio-activator

Bio-activator is an organic compost that contains naturally occurring microorganisms. It augments and stimulates the bacteria already present, resulting in a rapid decomposition of the waste. It accomplishes this by preventing the generation of odors. Bio-activator is a natural product that is free of harmful and toxic substances, making it environmentally friendly. It is composed of naturally occurring microorganisms that can stimulate bacteria to accelerate the decomposition process.

Cellulolytic microorganisms are contained in the bio-activator such as tiny organisms which live on cellulose. Agricultural waste cellulose is used as an energy source for the cellulolytic microbe in the bio-activator. This means that the cellulose in plant tissues degrades into simple carbohydrates that are readily absorbed by plants. The bio-activator is formulated as an inoculant and is applied to fresh rice straw or another field waste. This inoculant has been shown to speed up the composting process by up to one month. Once composted, the organic matter contributes to the increase of soil organic matter, which helps maintain soil fertility while decreasing the need for chemical fertilizers. It offers the benefits of extremely versatile and can be used on virtually any farm. The second benefits of using bio-activator is that it is non-toxic to the environment. The bio-activator can be in liquid, powder form (bulk or water-soluble bags), tablet and capsule form, pellet form, or slow-release little bars form (Sutrisno et al., 2020).

There are several methods for utilizing liquid organic fertilizer, one of which is by utilizing a natural bio-activator derived from abundant noni fruit and tomato waste. Bio-activators are a mixture of compounds that promote bacterial decomposition of hydrocarbons. Numerous studies indicate that a bio-activator derived from cow urine that has been fermented anaerobically for seven days has a greater effect on the growth and production of elephant grass biomass than other fertilizers (Semaun et al., 2018). Effective microorganism 4 (EM4) has previously been shown to be effective as a bio-activator in the production of liquid organic fertilizer using milkfish waste and additional vegetable waste as raw materials (Widyastuti & Lovakusuma, 2018).

The contents of the rumen, in the form of grass that has not been fermented and digested completely by the cattle, is one of the slaughterhouse wastes. Additionally, the rumen of cattle contains nutrients that microbes use as an energy source. The rumen also acts as a bio-activator, accelerating the maturation of organic compost, due to the presence of numerous microorganisms in the rumen contents. The presence of a diverse population of microorganisms in the rumen is critical for organic farming. Despite its nutritional value, the rumen contents of slaughtered ruminants such as cattle and goats are typically discarded. When used in the production of liquid and solid organic fertilizer, including as a bio-activator in the production of goat manure fertilizer, the waste is actually quite valuable (Pancapalaga et al., 2021).

Table 2.1. Nutrients content improvement in liquid organic fertilizer with the presence of bio-activator

Bio-activator	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 Plant Macronutrient

Macronutrients are important for the growth and production of plants. Macronutrients are important for plant growth and optimal health. Nitrogen (N), Phosphorus (P), and Potassium (K) are the three main macronutrients.

2.2.1 Nitrogen (N)

Nitrogen, the most common mineral in plants, is also a development inhibitor. Nitrogen is a component of all life's building blocks nucleic acids, amino acids, proteins, and biochemical goods. It accounts for about 2% of plant dry tissue. Following nitrogen absorption, nitrate is assimilating and reduced to nitrite and then to ammonium via nitrate and nitrite reductase, respectively. Ammonium is assimilated into organic molecules through to the glutamine synthetase/glutamate synthetase pathway in the root or shoot.

Since nitrogen is required for development, plants must be able to continuously monitor and react to nitrogen abundance in their climate. Apart from its nutritional value, nitrate has been recently identified as a signaling molecule in plants (Bouguyon et al., 2012). Nitrogen is important in a variety of biochemical processes. It imparts a dark-green color to plants and encourages the growth and regeneration of leaves, stems, and other vegetative sections. Additionally, it promotes root development. Nitrogen promotes fast early development, improves fruit production, accelerates the growth of leafy vegetables, and raises the protein content of fodder crops; it also promotes the absorption and use of other nutrients, such as potassium and phosphorus, and regulates overall plant growth (Bloom et al., 2015).

Nitrogen application process and timing are critical in crop development. Throughout agriculture's past, broadcasting application of nitrogen was well-known in the conventional farming method of Sindh, Pakistan (Leghari et al., 2016). It is still used today due to the ease and fast delivery of nitrogen fertilizers, but N loss is greater and plant utilization is limited. The traditional method of applying nitrogen has been phased out in favor of new methods such as fertigation and flooded application of nitrogenous fertilizer, in addition to foliar application. Recent advances in N implementation strategies have greatly reduced the probability of N failure and increased the plant's absorption of the nutrient. Prior to adding nitrogen, some critical factors must be addressed.

2.2.2 Phosphorus (P)

Phosphorus is a critical fertilizer for the development of plants. Phosphorus is a critical nutrient for the growth of plants and other living species. It is also a major component of agricultural fertilizers, which are typically obtained from a non-renewable phosphate rock supply (Imai et al., 2021). Phosphorus is one of the 17 important nutrients for plant development. No other nutrient may perform the functions that P does, and an adequate supply of P is needed for optimal growth and reproduction. Phosphorus is a major nutrient, which means that it is often lacking in crop production and is needed in comparatively large quantities by crops. The average phosphorus content of agricultural crops ranges between 0.1 and 0.5 percent (International Plant Nutrition Institute) (IPNI, 2019).

Phosphorus is needed for a variety of cellular processes, including the maintenance of membrane structures, biomolecule synthesis, and the creation of high-energy molecules. Additionally, it aids in cell differentiation, the activation/inactivation of enzymes, and carbohydrate metabolism (Razaq et al., 2017). According to Malhotra et al. (2018), P occurs in two ways in plant tissues: as a free inorganic orthophosphate or as organic phosphate esters. P is partitioned into compartments within plant cells based on its overall concentration. The cytoplasm contains the metabolically active Pi form, while excess P is retained in the vacuole and supplied to the cytoplasm upon cellular requirement.

2.2.3 Potassium (P)

Potassium (K) is a critical nutrient for the development of plants. It is known as a macronutrient due to the high amount of K taken up by plants during their life cycle. K acts as an activator for many essential enzymes, including those involved in protein synthesis, sugar transfer, nitrogen and carbon fixation, and photosynthesis. Potassium is normally found in greater concentrations in plants than any other nutrient but nitrogen. Certain plants and plant tissues accumulate a significant amount of potassium. Tobacco (Nicotiana tabacum L.) leaves, for example, can produce up to 8% potassium by dry weight and may exhibit potassium deficiency symptoms if the amount drops below 3%. It is critical in the development of yield and quality assurance (Xu et al., 2020).

Potassium is derived from four distinct sources in the soil. The soil minerals such as feldspar and mica are the primary source of potassium in the soil, accounting for 90 to 98 percent of the total. This potassium supply is only present in trace amounts to plants. The second type of potassium in soil is non-exchangeable potassium, which ranges from 1% to 10% and is correlated with the 2: 1 clay minerals (Prajapati et al., 2012). The non-exchangeable potassium supply serves as a potassium reservoir in the soil. The third type of potassium in soil is exchangeable or readily accessible potassium, which is present 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 root system of the plant and then supplemented by potassium at the exchange sites. The potassium contained in organic matter and the soil microbial community is a fourth source of potassium in the soil. This potassium supply in the soil offers a negligible amount of the potassium required for plant development (Prajapati et al., 2012).

2.3 Soil Parameter

Soil is a critical part of the natural environment. If the soil contains sufficient nutrients, has an appropriate pH, and is sufficiently moist, virtually everything will expand. According to Neina (2019), many believe that soil pH is only essential for the soil's chemistry and fertility. However, recognizing soil roles outside nutrient supply and the soil's position as a mechanism for plant growth necessitated a multidisciplinary examination of the soil and its properties in relation to wider ecosystem functions. This enables scientists to examine processes at many scales, from the landscape to the regional and global. Soil biogeochemistry is one method that exemplifies the multidisciplinary approach to soil science; it is concerned with biogeochemical processes. To a degree, soil ecosystem roles are inextricably linked to soil biogeochemical processes, which are the connections between biological, chemical, and geological processes (Neina et al., 2019).

2.3.1 pH

Due to its effect on a variety of other soil properties and processes influencing plant development, the soil reaction (pH) may be considered a main variable. Indeed, microorganism activity, as well as the solubility and supply of nutrients, are some of the most critical processes that are pH dependent. For example, most micronutrients are more accessible to plants in acid soils than in neutral-alkaline soils, which usually favors plant development (Gentili et al., 2018). In the natural world, the pH of the soil has a profound effect on the biogeochemical processes that occur in the soil. Thus, soil is referred to as the "master soil vector" because it influences a plethora of soil biological, chemical, and physical properties and processes that affect plant growth and biomass yield (Neina et al., 2019).

The pH of the soil has an effect on the solubility of nutrients. It also has an effect on the activity of microorganisms that are responsible for decomposing organic matter and performing the majority of chemical transformations in the soil. Thus, the pH of the soil has an effect on the availability of numerous plant nutrients. pH values between 6 and 7 are considered the most advantageous for plant development, since the majority of plant nutrients are easily accessible in this range. However, some plants have pH needs that are higher or lower than this range. Soils with a pH less than 5.5 often have limited calcium, magnesium, and phosphorus availability. Aluminum, iron, and boron are very soluble at these low pH values, but molybdenum is insoluble. Calcium and magnesium are plentiful with a pH of 7.8 or above. Molybdenum is also accessible if it occurs naturally in soil minerals. Iron, manganese, copper, zinc, and notably phosphorus and boron may be insufficiently available in high pH soils.

The pH of the soil determines the solubility, mobility, and bioavailability of trace elements, both of which affect their translocation into plants. This is largely determined by the partitioning of elements between solid and liquid soil phases during precipitation-dissolution reactions caused by pH-dependent charges in mineral and organic soil fractions. For example, negative charges are more prevalent at high pH values, while positive charges are more prevalent at low pH values. So according Neina (2019), trace elements are usually soluble at low pH owing to a high rate of desorption and a low rate of adsorption. At intermediate pH, the pattern of trace element adsorption decreases from almost no to almost total adsorption inside a small pH range referred to as the pH-adsorption edge.

2.3.2 Temperature

Soil temperature has an indirect effect on plant growth by influencing water and nutrient absorption, as well as root growth. A drop-in temperature results in a decrease in water and nutrient uptake at constant moisture content. Transport from the root to the shot and vice versa is slowed down at low temperatures. The temperature of the soil is a feature of both the heat flux within the soil and the heat transfers between the soil and the atmosphere (Onwuka et al., 2016). Temperate crops need cool soil temperatures to rise, which influences the abundance and diversity of soil microbial communities. Soil bacteria perform a variety of critical roles in the nutrient cycles of all major elements, including biomass, nitrogen, and phosphorus, which in turn influences the structure and function of the soil, thus sustaining temperate crop development (Hayat et al., 2010).

The typical temperature of the soil for bioactivity is between 65° and 75°F (18°-24°C). These levels are advantageous for the earth biota's regular life processes, which include organic matter breakdown, enhanced nitrogen mineralization, soluble substance intake, and metabolism (Albert, 2018). On the contrary, circumstances near freezing inhibit the activity of soil-dwelling microorganisms, and microorganisms cannot live below freezing. Reduced microbial activity is the cause of decreased organic matter breakdown and build up.

Solar radiation is the primary heat source in the soil. A thermometer is used to gauge the temperature of the soil. Seasonal and regular variations in soil temperature are possible because of fluctuations in radiant energy and energy transfer across the soil surface (Onwuka et al., 2018).

2.3.3 Moisture Content

The soil moisture quality is the most critical nutrient in the soil. Typically, soil moisture content is influenced by physical characteristics of the soil such as color, form, shape, and bulk density. Soil microorganisms improve soil consistency and are critical for soil environment processes such as nutrient cycling, organic matter decomposition, and bioremediation. Both changes in soil microbial communities because of ecosystem management and global change may have a significant impact on ecosystem dynamics, and since microorganisms are highly sensitive to changes and environmental stress due to their intimate relationship with their surroundings, interest in quantifying impacts on the biotic and abiotic components has increased in recent years (Onwuka et al., 2018). The physiological state of bacteria is influenced by soil moisture, which can hinder their ability to decompose such compounds (e.g., organic substrates). Water availability also influences substrate availability, and surface properties, and can influence microbial communities and behavior in general.

According to Laurenzi (2018) research on soil moisture, relatively coarse soil will do this at a soil moisture level of 75-50 percent, whereas medium soil will do it at a soil moisture level of 50-25 percent (clay soils will ball under pressure or simply not break even at low moisture content ranges). As such, it is critical for hops to maintain appropriate soil moisture. The research, which examined the effects of extra irrigation on hop productivity, soil quality, and insect infestations, concluded that while producing hops, it is critical to begin the growing season with the root zone as full of water as possible.

2.4 Growth Rate of Plants

Secondary metabolic products are required for plant development and related modifications. On the basis of their regulation of gene expression, these metabolic activities are governed by daily biological cycles dubbed circadian rhythms. Numerous genes in organisms are regulated by circadian rhythms, and these genes are intricately linked to govern physiological processes. Thus, when properly monitoring or directing the physiology or metabolism of plants, it is often necessary to consider the daily cycle. Additionally, global gene expression analysis, sometimes referred to as transcriptome analysis, is helpful for determining which genes are regulated by circadian rhythms (Tanigaki & Fukuda, 2018). Costs of transcriptome analysis utilizing next-generation sequencers have also decreased in recent years, and such research is now being performed on a wide variety of plants.

In compared to mammals, plants use extremely little energy to develop. Water and light plants will thrive in any substrate that has even a trace of mineral components. Outdoor plant cultivation is exposed to a variety of environmental circumstances that vary significantly in location and time. For instance, soil fertility and climatic conditions might vary fast depending on the season and/or geographic location. However, in order to assure reproducibility and consistency among studies, it is necessary to establish and manage precise growth conditions for research purposes. As a result, much effort and resources have been devoted to optimizing plant growth inside, under well-defined and regulated circumstances (Podar, 2013). The best soil type and volume, fertilizer and water dosages, light conditions and photoperiods for diverse plant species were explored. Subsequently, hydroponic systems with nutrient solutions that have a more homogeneous mineral composition and are easy to control were developed. This has the benefit of establishing direct contact between the root systems and the essential minerals, which are already in their ionic state and evenly dispersed throughout the substrate (Podar, 2013). As a result, macro- and micronutrient formulations tailored to the specific requirements of each plant species have been devised.

2.4.1 Number of Leaves

Photosynthesis is carried out by leaves, which are specialised structures that supply energy to plants. On woody stems, leaves emerge from nodes right below an axillary bud and are frequently petiolate, which means they are made of a blade and a stalk-like petiole, as opposed to simple leaves. Stipules, which are two little leaf-like flaps that are connected at the base of the petiole, may be present. Stipules on leaves and stems may sometimes be transformed into spines, thorns, or prickles as a result of this transformation. Some leaves are sessile, which means they do not have petioles and have blades that are directly linked to the stem rather than via the petiole (Nakano, 2020). When a node produces a new leaf, the number of leaves produced varies depending on the plant species. It is called a helix when a single leaf arises from each node and when the stem is kept straight by the leaves.

2.4.2 Plant Height

A plant species' ecological strategy is highly dependent on its height. It is critical to a species' carbon uptake strategy since height is a primary predictor of a plant's capacity to compete for light and because height correlates with leaf mass fraction, leaf area ratio, leaf nitrogen per area, leaf mass per area, and canopy area. Plant height also plays a role in a coordinated suite of life-history attributes that includes seed mass, time to reproduction, lifespan, and the quantity of seeds a plant may generate every year. These characteristics are critical for a species' survival, growth, and reproduction. Additionally, there is a correlation between plant size and metabolic rate and maximum population density (Zhou et al., 2020). Apart from playing a critical role in plant ecological strategy, plant height has a significant impact on important ecosystem variables such as carbon sequestration capacity (via its relationship to plant biomass) and animal diversity (for example, bird and mammal species diversity is highly correlated with foliage height diversity).

2.4.3 Length and Width of Leaf

The leaf is the primary organ of plants for photosynthesis and transpiration, and the characteristics of the leaf are directly associated with information about plant development. At the moment, the length and breadth of a leaf are key shape factors that may be employed in tasks such as leaf area calculation and automated identification. The linear distance between the leaf petiole and tip, the shortest distance between the leaf petiole and tip, and the extraction skeleton between the petiole and tip have all been measured using high-performance technology. Leaf measuring techniques such as grid and scanning are often employed, and although they are easy to install, they do demand a significant amount of people and time.

2.5 Comparison of Plants

2.5.1 Alternanthera Spinach (Sissoo Spinach)

2.5.1.1 Background

Sissoo Spinach is a low-growing perennial that forms a compact mound to 30cm in height. In ideal tropical conditions, if allowed to spread, it can form a creeping ground cover. It has a crinkled or 'bubbly' leaf structure and a decorative rich green coloration. In a nutshell, it resembles a salad green, which is how it is used in its native Brazil. It is also used in cooking as an alternative to spinach. *Alternanthera Sissoo* is also known as Sissoo, Sissoo Spinach, Samba Lettuce, and Poor Man's Spinach (Organic Brazilian Spinach Alternanthera Sissoo Plant - Herb Cottage, n.d.).

2.5.1.2 Properties

Sissoo spinach is a robust, tropical plant that thrives in northern Australia where temperate vegetable greens may not. In contrast, this plant thrives in places like Florida. Once planted, it will also survive in these places all year, ensuring a continual supply. It should be handled as a hot weather annual in temperate countries and studied to see how the plant reacts to local circumstances.

This plant benefits from richer soil and the application of fertilizer on a yearly basis. It is tolerant to direct sunlight. Sissoo, on the other hand, thrives in 50% or more shadow. This implies it may be grown under trees to simulate a tropical habitat. Sissoo, on the other hand, is highly tolerant to dry and hot circumstances once established. Sissoo does not blossom when gathered on a regular basis. It will do so if the leaves are not harvested often enough and if the weather is too hot and dry.

Figure 2.2. *Sissoo Spinach* (Brazilian Spinach)

2.5.2 *Ipomoea Aquatica* (Water Spinach)

2.5.2.1 Background

Ipomoea Aquatica, often known as water spinach, is a popular vegetable in Asia, particularly in Malaysia, Hong Kong, and Taiwan. This delicious vegetable is a member of the Convolvulaceae family. Water spinach is a perennial aquatic or semi-aquatic plant that prefers to crawl on damp soil or sand rather than floating in water. Countries such as Southern Asia, Bangladesh, China, and India have traditionally used Ipomoea Aquatica in folk medicine to treat a variety of ailments, including diabetes, liver dysfunction, constipation, and arsenic poisoning, due to its high nutritional content and digestible green greens (Yusufirashim et al., 2019). Additionally, water spinach is high in minerals such as flavonoids, phenolics, and carotenes. Due to the ease with which water spinach grows, its short time to harvest, and its adaptability to environmental changes, the plant is ideal for cultivation. However, water spinach may acquire foreign elements such as Cadmium, Zinc, and Copper, allowing it to be utilized as a study sample plant (Yusufirashim et al., 2019).

2.5.2.2 Properties

The fragile stems and leaves are delicious and may be boiled or fried. Protein (3 g/100 g fresh weight), calcium (81 mg/100 g fresh weight), provitamin A (4000-10.000 IU), and vitamin C (30-100 mg/100 g fresh weight) are abundant in the shoots (Pinker et al., 2007). As a result, water spinach is an important source of vitamins in nations that rely heavily on rice. Water spinach is classified into two types: lowland or aquatic and upland or dry. The dry kind of water spinach is mostly farmed in Vietnam but is also commercially farmed on raised beds in Florida.

Figure 2.3. *Ipomoea Aquatica* (Water Spinach)

2.5.3 *Ficus Elastica* (Rubber Plant)

2.5.3.1 Background

Ficus Elastica, sometimes called India Rubber (although its geographical origins are unknown), was a significant source of latex in the early nineteenth century and was extensively planted across tropical Asia. *Ficus Elastica* is a well-known plant as an interior and outdoor decorative (Harrison et al., 2017). It is a widespread street and park tree across the tropics, and as an interior decorative, it is one of the most extensively distributed plants today. *Ficus Elastica* is a member of the fig genus, which comprises over 750 species worldwide with a fairly pan-tropical distribution. All figs contain latex, as do other members of the Mulberry family (Moraceae). Although F. elastica's latex is unusually abundant and thick, which likely explains why it is cultivated for latex manufacturing.

2.5.3.2 Properties

The Rubber Tree is a popular indoor pot plant. There are numerous stems and a spreading, uneven canopy on this evergreen tree with enormous, glossy leaves. Rubber trees may grow up to 100 feet tall in the rainforest, but are more often seen between 25-40 feet. They are perfect as a screen, shade, patio, or exhibition tree. Its grittiness stands out in the scenery. Its use as a street tree is limited by its tendency to break apart in strong winds. The tree might be reinforced by removing weak tight-angle crotches and spacing big lateral branches along a single core trunk. To prolong the tree's life in the landscape, remove multiple trunks and reduce lateral branches to half the diameter of the trunk.

Figure 2.4. *Ficus Elastica* (Rubber Fig)

CHAPTER 3

METHODOLOGY

3.1 Materials

The list of materials used in this study are summarized in Table 3.1 as shown below.

Table 3.1. List of materials for production of liquid organic fertilizer

No.	Material	Usage	Supplier
1.	Oil palm empty fruit bunch fiber waste	Sample of waste	**Felda Palm Industries Sdn Bhd**
2.	Commercial liquid organic fertilizer	Sample of commercial fertilizer	**Shopee**
3.	Sugarcane molasses	Ingredient	**Shopee**
4.	Cattle urine	Ingredient	**Lazada**
5.	Fresh noni fruit	Ingredient	**Shopee**
6.	Soil	Sample of soil	**Nursery**
7.	Sissoo Spinach	Check effectiveness of liquid organic fertilizer	**Nursery**
8.	Rubber Plant	Check effectiveness of liquid organic fertilizer	**Nursery**

3.1.1 Equipment

The lists of equipment used in this study are summarized in Table 3.2 as shown below.

Table 3.2. List of equipment for production of liquid organic fertilizer

No.	Material	Usage
1.	Soil analyzer	To check the pH and temperature
2.	Pot	Planting the plants
3.	Digital moisture meter measurement	To check the moisture content
4.	Digital weighing scale reading	To weight the amount of sample used

3.1.2 Selection of Commercial Liquid Organic Fertilizer

The selection of the product organic fertilizer liquid natural pesticide for green leaf or flowers as commercial organic liquid fertilizer is because the product is cheap with the price of RM18.00. Besides, it is 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 strengthens plants, reduce abscission of flower & fruits. So, this product is 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 oil palm empty fruit bunch fiber (OPEFBF) waste were collected at Felda Palm Industries Sdn Bhd at Lepar Hilir. Next, OPEFBF waste were drying to reduce the moisture content in the waste. The moisture content must be lower than 10% just to make sure the waste can accommodate to the formulation. From OPEFBF waste, it come out with three formulation which are formulation A, formulation B, and formulation C. Formulation A consist of OPEFBF waste 1 kg, bio activator 0.04 L, molasses 50 g and cattle urine 2 g. Formulation B consist of OPEFBF waste 1 kg, bio activator 0.04 L and molasses 50 g. Formulation C consist of OPEFBF waste 1 kg and molasses 50 g. Each of the formulation will be added 1L of water. Lastly, the materials of each formulation were mixed and incubate for 14 days in paint pail using anaerobic system.

3.2.2 N, P, K Testing on Formulation

The nitrogen, phosphorus and potassium content in each formulation were being sent to central laboratory to be tested by using ICP-OES which is a trace-level, elemental analysis technique that uses the emission spectra od a sample to identify, and quantify the elements present. The same technique was repeated to check potassium and phosphorus content in each sample.

3.2.3 Experimental Procedure

There were 5 types of pot that consists of different formulation of liquid organic fertilizer including the soil without any mixture and commercial fertilizer.

Table 3.3 Experimental sample for *Alternanthera Sissoo* (Sissoo Spinach) and *Ficus Elastica (*Rubber Plant)

Pot	**Sample**	**Composition**
1	Formulation A	OPEFBF waste 1 kg + Bio-activator 0.04 L + Molasses 50 g + Cattle Urine 2 g
2	Formulation B	OPEFBF waste 1 kg + Bio-activator 0.04 L + Molasses 50 g
3	Formulation C	OPEFBF waste 1 kg + Molasses 50 g
4	Commercial Fertilizer	Readymade Fertilizer
5	Control	Soil without adding fertilizer

3.2.4 Plant Planting

The plants were planted in a method known as stem cutting. This method only applied for *Alternanthera Sissoo* (Sissoo Spinach), for *Ficus Elastica* (Rubber Plant) it does need to this method. The healthy-looking branch tip includes leaves were selected in this stem cutting process. The branch tip has been cutting to 4-6 inches long. The leaves in the bottom 2 inches of the cutting has been removed. The cutting was manually sown at a depth of 1/2 to 1 inch, partially covering the soil and keeping it moist.

3.2.5 Soil Parameter Monitoring Analysis

Using a soil analyser and a digital moisture metre, the pH, temperature, and moisture content of all of the treatments were measured every day for a total of seven days. The soil analyser and digital moisture meter were dipped into the soil for roughly two to three minutes at a depth of approximately two-thirds of an inch before obtaining the reading. The pH level must be between 6 and 7 in order to be in the appropriate range for plant development, and the temperature must be between 23°C and 35°C. The moisture content must be between 70 percent and 80 percent in order to ensure that the plant is acceptable at the moisture level.

3.2.6 Phytomorphology Analysis of *Alternanthera Sissoo* (Sissoo Spinach) and *Ficus Elastica (*Rubber Plant)

Four parameters were used in this project which is number of leaves, plant height, length and width of the leaf to observe the growth performance of *Alternanthera Sissoo* (Sissoo Spinach) and *Ficus Elastica (*Rubber Plant) treated with five different treatments. For number of leaves, the leaves were counted and recorded, including the tips of new leaves just beginning to emerge. For plant height, the height was measured from the top of the soil to the top of the main plant stem. Lastly, the length and width of the plants were measured using measuring tape. 5 leaf had been chosen and the length and width were measured to the point where the leaf joins the stalk at the other end as shown in Figure 3.1.

Figure 3.1. Measuring the length and width of the leaf using measuring tape

3.2.7 Flowchart of Liquid Organic Fertilizer Production

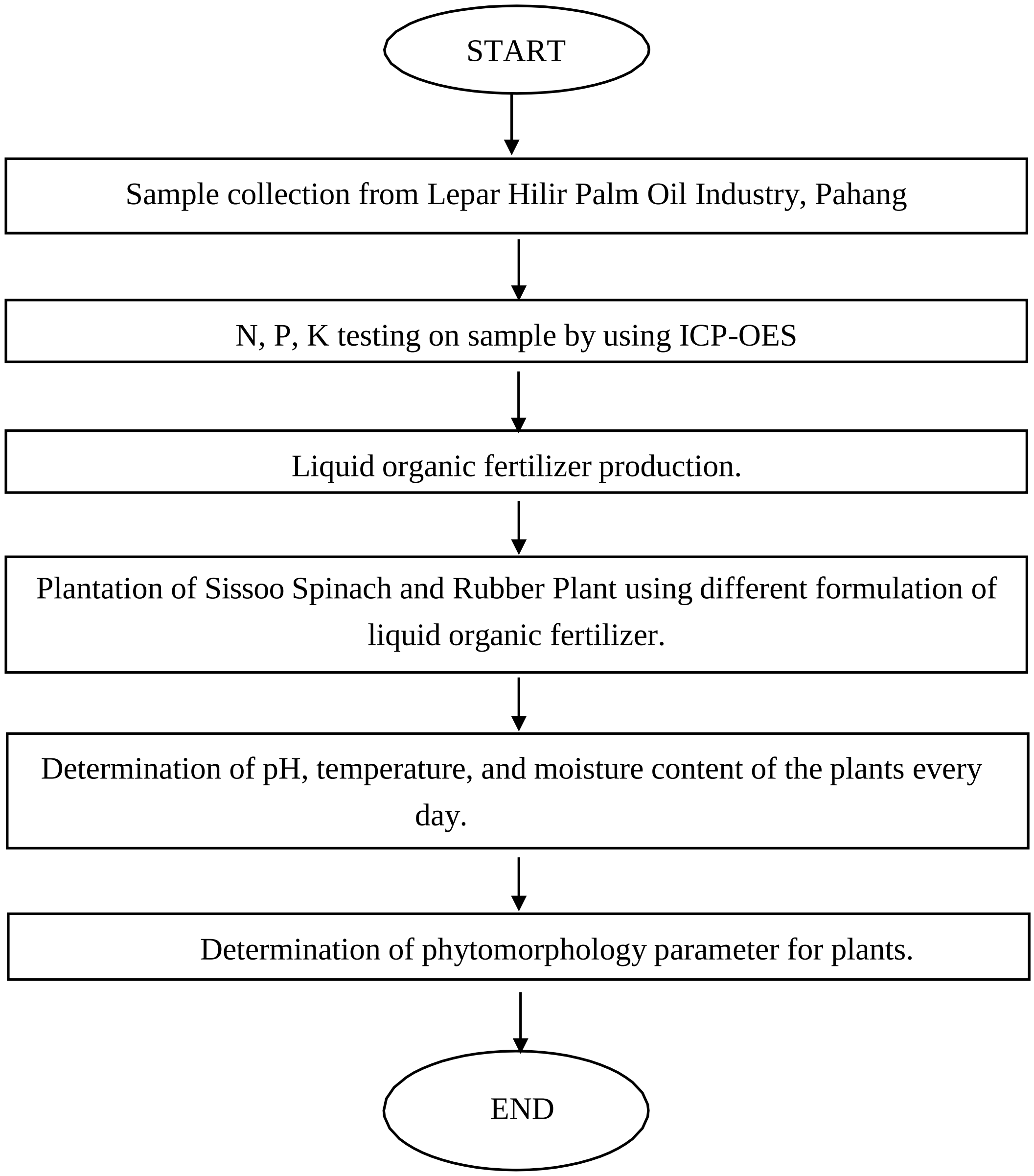

Figure 3.2. The flowchart of production of liquid organic fertilizer

This experiment began with collecting samples of oil palm empty fruit bunch fiber (OPEFBF) waste at Felda Palm Industries Sdn Bhd's Lepar Hilir factory. An authorization letter was delivered to the factory's manager, Mr. Mohamad Nor Hafizi bin Kassim. Three kilograms of OPEFBF waste were collected from the factory and used as the primary raw material for liquid organic fertilizer production. The OPEFBF waste was sent to the central lab at UMP Gambang's Cariff building for NPK analysis using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES). The OPEFBF waste has been dried in the sun to reduce the moisture level to less than 10%. Three formulations of liquid organic fertilizer were created and labeled as formulations A, B, and C. One-kilogram OPEFBF waste, 0.04 L bio activator, 50 g molasses, and 2 g cow urine Formulation A. One-kilogram OPEFBF waste, 0.04 L bio activator, and 50 g molasses make up Formulation B. Formulation C is composed of one kilogram of OPEFBF waste and 50 g of molasses. After producing the liquid organic fertilizers, they were sprayed over the plants. Each formulation was put in plastic paint pails and will ferment for two weeks.

Following that, the seed sowing of plant seeds was completed. Sissoo Spinach and Rubber Plant needed two daily watering, and the plants' status was monitored during this seed sowing in terms of soil temperature, pH, and moisture content. After two weeks, the spinach plant began fertilizing with the five various kinds of samples. Following that, daily pH, temperature, and moisture content were measured using a soil analyzer and a digital moisture meter for 28 days. After two weeks, the spinach plant was harvested. The pyhtomorphology of the plant was determined by counting the leaves, the plant's height, length, and width of the leaf.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results on Soil Moisture Content of Five Different Treatments

4.1.1 Soil Moisture Content of *Alternanthera Sissoo* (Sissoo Spinach) for Four Weeks

The findings of the moisture content experiment reveal that the soil condition for Sissoo Spinach changes according on which of the five different treatments is utilized in this experiment. Figure 4.1 illustrates that all of the treatments in this experiment had a moisture content ranging from 70 % to 80 %. In week four, it was discovered that commercial fertilizer had the maximum moisture level when compared to formulation A, formulation C, formulation B, and the control treatment, with a moisture content of 79.1%. 76.7%, 78.3%, 77.1%, and 75.1% are the corresponding percentages for the four treatments.

According to the findings, the moisture content was highest in week three when compared to the previous weeks. The soil moisture in this example was impacted by the temperature that was present at the time. Week three brought severe rains to the location of the experiment, which coincided with the third week of the experiment.

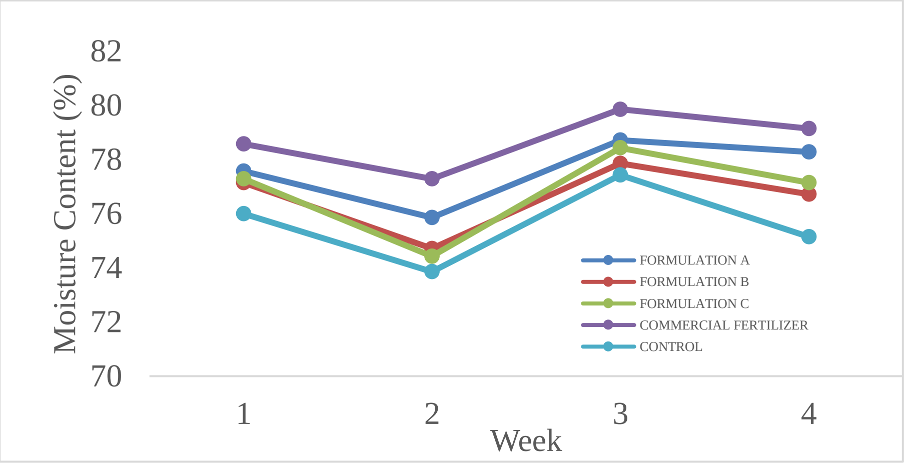

Figure 4.1. Soil Moisture Content of Different Treatments for Sissoo Spinach

4.1.2 Soil Moisture Content of *Ficus Elastica* (Rubber Plant) for Four Weeks

The findings of the moisture content experiment indicate that the soil condition of the Rubber Plant varies depending on which of the five different treatments is utilized in this experiment. Figure 4.2 depicts the moisture content of all the treatments in this experiment, which ranges from 70 percent to 80 percent. The commercial fertiliser had the highest moisture content in week 4 when compared to formulation A, formulation C, formulation B, and the control treatment, with moisture contents of 79.6 percent, 77.9 percent, 77.3 percent, 76.7 percent, and 75.1 percent. The moisture content of formulation A, formulation C, formulation B, and the control treatment were all higher than the fertilizers.

The amount of moisture present in the treatments reveals how well the formulations are able to retain moisture. Moisture content for all treatments demonstrates that the outcomes were impacted by the addition of water to the soil to ensure that the moisture content remained within a reasonable range throughout the day. According to the findings, the graph finding was comparable to the moisture content for Sissoo Spinach, which is in week 3 of the experiment, the moisture content was the greatest compared to the other weeks of the experiment.

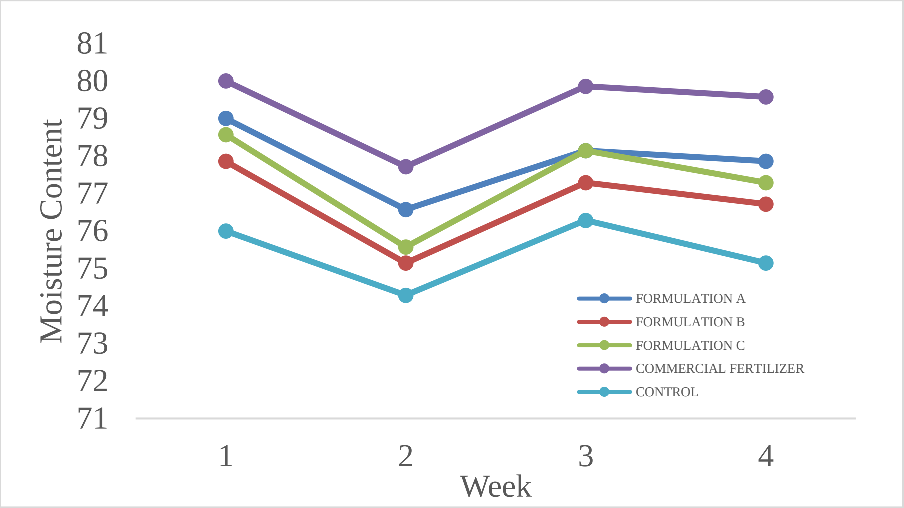

Figure 4.2. Soil Moisture Content of Different Treatments for Rubber Plant

4.2 Results on Soil pH Reading of Five Different Treatments

4.2.1 Soil pH on *Alternanthera Sissoo* (Sissoo Spinach) for Four Weeks

Because of the formulation and OPEFBF waste utilized as a substrate in this experiment, the pH suggests that the soil condition for Sissoo Spinach has changed. As shown in Figure 4.3, the pH readings for all treatments are rising, and the pH values for all treatments are within the range of pH6.8 to pH7. During the last week of the observations, it was discovered that commercial fertilizer had the same pH level as formulation A and that the control treatment had pH 7. Formulation B and formulation C have the same pH value of 6.9, the same as in formulation A.

Results showed that commercial fertilizer was in the pH range that was most favorable for plant development, which was neutral pH that was slightly alkaline. The pH of the liquid organic fertilizer was not insignificant in any of the three formulations of the liquid organic fertilizer tested. The pH of the control treatment was initially a touch acidic, but over a week, it gradually became closer to neutral pH levels. In particular, the findings show that Sissoo Spinach can germinate and grow in soils with varying pH levels. However, its performance in developing vegetative features and reproductive investment rises when the soil response is somewhat acidic at pH6. As a consequence of these findings, the optimal pH for germination was shown to be somewhere between pH6 and pH7. This experiment showed that plants grown at pH7 outperformed those cultivated at pH6 in the majority of the intermediate pH levels investigated.

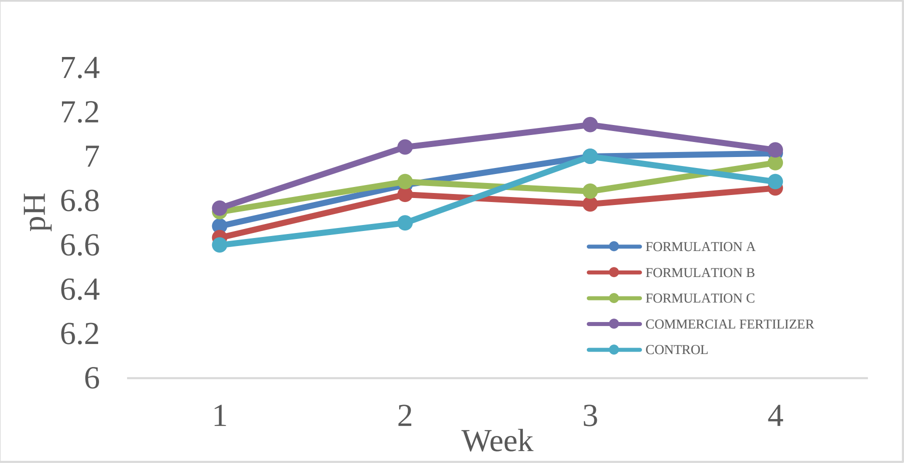

Figure 4.3. Soil pH of Different Treatments for Sissoo Spinach

4.2.2 Soil pH on *Ficus Elastica* (Rubber Plant) for Four Weeks

The pH of the soil for Rubber Plant varies as the formulation and OPEFBF waste as a substrate utilised in this experiment alter. Figure 4.4 depicts a growing pH reading in all treatments, as well as a pH value ranging from pH6.8 to pH7 in all treatments. During the last week of the observations, commercial fertilizer was discovered to have the same pH level as control treatment, which had a pH of 7.0 and Formulation A who had pH of 6.8 The pH of Formulation B and Formulation C is likewise the same, which is 6. The pH range of pH5.5 to pH6.5 is ideal for plant development since nutrients are readily available. This is also true for most soil bacteria, in part because plants grow better in this range and generate more root exudates as a carbon source accessible for microbial survival and proliferation (Msimbira & Smith, 2020). The plant grows well in a neutral to slightly alkaline pH range.

The findings of this study demonstrate that pH levels in the intermediate/slightly acid range are generally the most favorable for the development and reproduction of the Rubber Plant. The majority of plant nutrients are known to be most readily accessible to plants in intermediate/sub-acid pH ranges and to be compatible with root development in a variety of soil types. Plants growing in soils that are excessively acidic or too calcareous (i.e., alkaline) significantly alter their capacity to absorb micro- and macronutrients, and they are continually vulnerable to either mineral shortage or metal toxicity, depending on the soil type (Offord et al., 2014).

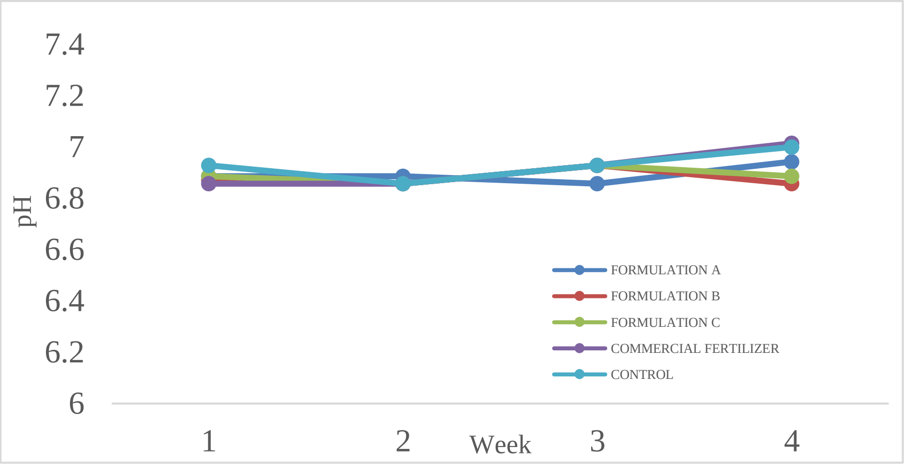

Figure 4.4. Soil pH of Different Treatments for Rubber Plant

4.3 Results on Soil Temperature Reading of Five Different Samples

4.3.1 Soil Temperature on *Alternanthera Sissoo* (Sissoo Spinach) for Four Weeks

Every day for four weeks, the soil temperature readings of all the treatments for Sissoo Spinach were taken and recorded. Figure 4.5 shows the average data for each week, which was collected and charted. In Figure 4.5, it can be seen that the temperature range for all treatments was between 28.0°C and 29.5°C. Because of the rainy season, the temperature dipped somewhat in week 3 and began to rise in week 4. The temperature began to rise in week 4 as well. During the last week of the observations, it was discovered that commercial fertilizer had the highest temperature, surpassing formulation A, formulation C, formulation B, and a control treatment, with temperatures of 28.7°C, 29.0°C, 29.1°C, 29.3°C, and 29.0°C, respectively, compared to the other formulations.

It because Sissoo Spinach grows best in wet soil, the growth of plants at soil temperature in week three generated larger height at lower temperatures and reduced height at higher temperatures. This is because Sissoo Spinach grows best when planted in moist soil. The disparities that had arisen as a result of the original therapy had been resolved. Spinach thrives at temperatures ranging from chilly to cold. It is best for the seeds to germinate when the soil temperature is between 4.4°C and 27.9°C. While the ideal soil temperature for seed germination is between 15.6°C and 21.1°C, the fact that spinach can still sprout at 4.4°C should give an indication of how tolerant spinach is of being kept in a cool environment.

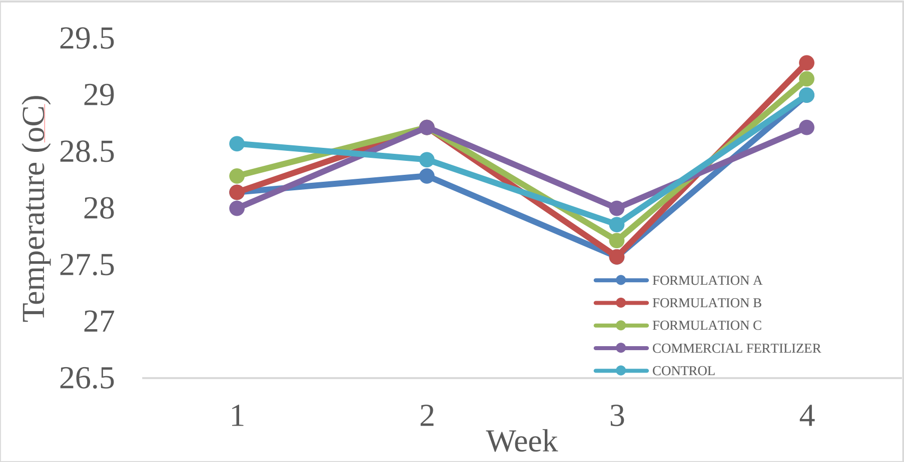

Figure 4.5. Soil Temperature of Different Treatments for Sissoo Spinach

4.3.2 Soil Temperature on *Ficus Elastica* (Rubber Plant) for Four Weeks

The soil temperature readings for all of the Rubber Plant treatments were obtained every day for four weeks, and the results were compared. According to Figure 4.6, the temperature range for all of the treatments was between 27.0 and 29.0 degrees Celsius. During the last week of the observations, it was discovered that formulation C had the highest temperature, surpassing commercial fertilizer, formulation A, formulation B, and the control treatment, with temperatures of 29.0°C, 28.9°C, 28.6°C, 28.9 °C, and 28.9 °C, respectively, in comparison to the other formulations. It was discovered that there was no statistically significant difference in the temperature change between the three formulations. On the other hand, it was discovered that formulation A had the highest temperature among the three formulations tested. Because of the wet season, it was discovered that all of the treatments maintained the same tendency, — in other words, reduced in week 3.

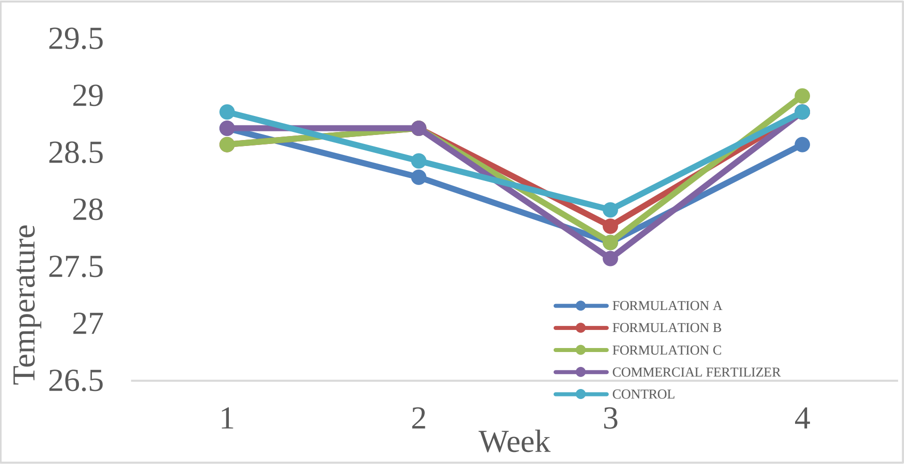

Figure 4.6. Soil Temperature of Different Treatments for Rubber Plant

4.4 Phytomorphology Analysis of *Alternanthera Sissoo* (Sissoo Spinach) and *Ficus Elastica* (Rubber Plant)

4.4.1 Number of Leaves

After three weeks of monitoring, the application of liquid organic fertiliser had a statistically significant effect on the number of leaves in Alternanthera Sissoo (Sissoo Spinach) and Ficus Elastica (Rubber Plant). Table 4.1 shows the average number of leaves in varied degrees of treatment for each level of treatment during a one-week period. Commercial fertiliser had the largest mean number of leaves for the first observations beginning in week one, followed by the control treatment, formulation A, formulation C, and formulation B. Commercial fertiliser had the largest mean number of leaves for the first observations beginning in week 2, followed by the control treatment, formulation A, formulation C, and formulation B. During the two-week testing, the number of leaves among the five treatments remained consistent, with the commercial fertiliser recording the most leaves, followed by formulations A and B, formulation C, and lastly the control.

Rubber Plant leaf counts are shown in Table 4.2 as an average of the number of leaves under various levels of treatment. Starting with week 1, it was discovered that the control treatment and formulation C had the largest mean number of leaves for the first observations, followed by the control treatment, formulation A, formulation B, and commercial fertilizer, respectively. After two weeks of testing, the results revealed that the number of leaves in each of the five treatments had changed, with the commercial fertilizer producing the highest number of leaves, followed by formulation A, formulation B, formulation C, and the control treatment, and the control treatment producing the lowest number of leaves. In the case of Rubber Plant, there were no statistically significant differences between the five treatments, which was similar to the findings for Sissoo Spinach.

The three formulations had no statistically significant effect on the number of leaves, but when compared to commercial fertilizer, the value of the three formulations was much greater than the other treatments. Furthermore, the interaction between those treatments did not have a statistically significant impact on the number of leaves.

Table 4.1. Average number of leaves of *Alternanthera Sissoo* (Sissoo Spinach)

Treatment	Week 1	Week 2	Week 3
Formulation A	9	12	13
Formulation B	8	12	13
Formulation C	9	11	13
Commercial Fertilizer	12	15	15
Control	10	11	13

Table 4.2. Average number of leaves of Ficus Elastica (Rubber Plant)

Treatment	Week 1	Week 2	Week 3
Formulation A	14	15	12
Formulation B	12	12	12
Formulation C	13	14	11
Commercial Fertilizer	11	11	15
Control	13	13	11

4.4.2 Plant Height

In the following table, the average plant height for Brazilian Spinach is shown for various levels of treatment. After one week of observations, it was discovered that commercial fertiliser had the greatest mean number of leaves, followed by formulation A, formulation B, control treatment, and formulation C, which was the last to be discovered. It was discovered that after two weeks of conducting the experiment, there was no difference in the number of leaves among the five treatments except for the highest treatment, where the plant height was measured using commercial fertiliser and the other four treatments (formula A, formulation B, control treatment and formulation C).

The average number of leaves under various levels of treatment for the Rubber Plant is shown in the following table: 4.4. As early as week 1, it was discovered that the control treatment had the greatest mean of plant height for the first observations. This was followed by the commercial fertiliser treatment (formulation A), the formulation C, and the formulation B. After two weeks of testing, the results revealed that the plant heights of the five treatments varied, with formulation C having the highest plant height recorded, followed by formulation A, commercial fertiliser, control treatment, and formulation B. The results also revealed that the plant heights of the five treatments varied.

Both the administration of liquid organic fertiliser and the control treatment had a statistically significant influence on plant height, according to the results. Cow dung was one of the materials utilised in the creation of liquid organic fertiliser under the category of liquid organic fertiliser, and it also helped to increase the height of the plants. Cow manure applied to the soil at varying levels may have improved soil fertility and soil structure, increased soil organic matter, and increased microbial activity. The nutrients released from the manure may have supported and enhanced rapid root development, which may have resulted in increased leaf growth.

Table 4.3. Average plant height of *Alternanthera Sissoo* (Sissoo Spinach)

Treatment	**Week 1**	**Week 2**	**Week 3**
Formulation A	5.05cm	5.55cm	5.73cm
Formulation B	4.40cm	4.45cm	5.48cm
Formulation	3.18cm	3.95cm	4.80cm
Commercial Fertilizer	5.20cm	5.95cm	6.95cm
Control	3.50cm	4.10cm	4.60cm

Table 4.4 Average plant height of *Ficus Elastica* (Rubber Plant)

Treatment	Week 1	Week 2	Week 3
Formulation A	27.0cm	27.7cm	27.3cm
Formulation B	25.0cm	25.2cm	26.1cm
Formulation C	25.6cm	26.0cm	27.6cm
Commercial Fertilizer	26.5cm	26.9cm	27.2cm
Control	26.0cm	26.0cm	26.1cm

4.4.3 Length of Leaf

The average leaf length at various levels of treatment for Sissoo Spinach is shown in Table 4.5. From week 1, it was seen that commercial fertiliser had the greatest mean leaf length, followed by formulation A, control treatment, formulation C, and formulation B. After two weeks, the leaf lengths were consistent throughout the five treatments, with commercial fertiliser achieving the maximum plant height, followed by formulation A, formulation C, formulation B, and control treatment.

The average length of a leaf at various levels of treatment for the Rubber Plant is shown in Table 4.6. From week 1, it was determined that the control treatment had the greatest mean leaf length for first observations, followed by formulation A, formulation B, formulation C, and commercial fertiliser. After two weeks, the length of leaf was varied among the five treatments, with the formulation A achieving the maximum plant height, followed by formulation B, commercial fertiliser, formulation C, and control treatment

According to the findings, potassium plays a significant influence in this topic. Leaf production fluctuated dramatically as potassium rates varied. Commercial fertiliser had the greatest leaf length throughout all development stages, followed by the other four treatments. At all development phases, the control plant had the shortest leaf length.

This finding demonstrates that potassium has a beneficial influence on the development of leaves in both plants.

Table 4.5. Average length of leaf of *Alternanthera Sissoo* (Sissoo Spinach)

Treatment	**Week 1**	**Week 2**	**Week 3**
Formulation A	0.75cm	1.42cm	1.58cm
Formulation B	0.57cm	0.88cm	1.08cm
Formulation C	0.67cm	1.28cm	1.43cm
Commercial Fertilizer	0.98cm	1.78cm	1.93cm
Control	0.70cm	1.34cm	1.40cm

Table 4.6. Average length of leaf of *Ficus Elastica* (Rubber Plant)

Treatment	**Week 1**	**Week 2**	**Week 3**
Formulation A	17.48cm	17.65cm	17.9cm
Formulation B	16.64cm	16.78cm	17.1cm
Formulation C	17.1cm	17.4cm	17.6cm
Commercial Fertilizer	16.78cm	16.9cm	17.4cm
Control	16.56cm	16.7cm	16.8cm

4.4.4 Width of Leaf

The average width of the leaf for Sissoo Spinach is shown in Table 4.7, which depicts the average width of the leaf in various levels of treatment. During the first week of observations, it was discovered that commercial fertiliser had the largest mean width of leaf, followed by formulation A, the control treatment, formulation B, and formulation C. This remained the same for all subsequent weeks of observations. After two weeks of testing, the breadth of leaf among the five treatments remained the same, with the commercial fertiliser recording the maximum plant height, followed by formulation A, formulation B, formulation C, and the control treatment, all of which were followed by the control treatment.

For Rubber Plant, Table 4.8 depicts an average width of leaf for each degree of treatment applied to the plant. From the first week of observations, it was discovered that formulation A had the greatest mean width of leaf for the first observations, followed by formulation C, formulation B, commercial fertiliser, and the control treatment. After two weeks of testing, the width of leaf among the five treatments remained constant, with formulation A recording the highest plant height, followed by formulation C, commercial fertiliser, and formulation B. After two weeks of testing, the width of leaf among the five treatments remained constant, with the highest plant height recorded by formulation A. According to the findings, the breadth of the leaf had a value that was equivalent to the length of the leaf.

Table 4.7. Average width of leaf of *Alternanthera Sissoo* (Sissoo Spinach)

Treatment	Week 1	Week 2	Week 3
Formulation A	0.83cm	1.27cm	1.31cm
Formulation B	0.69cm	1.04cm	1.05cm
Formulation C	0.66cm	1.06cm	1.13cm
Commercial Fertilizer	1.20cm	1.52cm	1.62cm
Control	0.76cm	0.83cm	1.02cm

Table 4.8. Average width of leaf of *Ficus Elastica* (Rubber Plant)

Treatment	Week 1	Week 2	Week 3
Formulation A	10.06	10.61	10.72
Formulation B	9.68	9.79	9.95
Formulation C	9.71	10.03	10.33
Commercial Fertilizer	9.46	9.46	10.16
Control	9.06	10.14	10.32

When various kinds of formulations are utilized, all metrics reveal that there is no statistically significant difference between the five treatments when they are applied. Among the three formulations, Formulation A had the highest mean across all measures, including leaf number, plant height, leaf length, and leaf breadth. Formulation B had the highest mean across all metrics, except leaf number. Furthermore, if microorganisms can develop in an environment that is conducive to their growth, they may be extremely effective at dissolving nutrients and making them available to plant growth. As a consequence, the microbes in the combination had a favorable influence on the plant's capacity to absorb nutrients. The use of OPEFBF waste in conjunction with a bio-activator, urea, and molasses may prove to be a beneficial technique for increasing growth and yield while simultaneously lowering environmental pollution levels.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As the conclusion of this study, organic residues from oil palm fruit bunch fibre waste, molasses, bio-activator, and urea were used as substrates for the production of liquid organic fertiliser following a 14-day fermentation period. Three formulations were developed, each with a distinct value for each of the four principal organic substrates used in the experiment. There is no statistically significant difference between the treatments for any of the criteria, including soil variables and plant development characteristics, when comparing the treatments. It was discovered that the plant cultivated with Formulation A had the most favourable growth characteristics when the impacts of liquid organic fertiliser on the development of Sissoo Spinach and Rubber Plant were investigated. There were many of them, including soil properties that were the most similar to those found in commercial fertiliser. In addition, Formulation A was selected as the best combination since it had the greatest mean of all parameters among the three formulations, making it the best combination (Formulation A, Formulation B and Formulation C). Furthermore, liquid organic fertiliser made from oil palm fibre fibre waste has the potential to replace inorganic fertilisers in nurseries if it is used effectively.

5.2 Recommendations

For the suggestion of this project, it is best to take to root growth reading, since it can show the difference between nitrogen in each formulation and the development of the roots. In order to acquire a thorough image of the root system, various parameters will need to be measured. In many circumstances, just approximate estimates of root presence or function may be required; nevertheless, much of the work done with plant roots has been to increase our understanding on the interrelationships of root measurement with function to produce key root parameters to measure. Several essential root system metrics include: root length, root weight, root volume, root shoot, specific root length, branching pattern, horizontal distribution, root hair density, root uptake capacity, root hydraulic conductivity, and root vitality. These root features may predict critical root activities within and across species, including respiration, water and nutrient uptake, longevity, and decomposition.

Other than that, the waste needed to use the oven for drying for measuring the moisture content of the trash. In oven drying procedures, the sample is heated under specific circumstances, and the loss of weight is utilised to determine the moisture content of the sample. This is more precise approach to acquire the exact quantity of moisture. The moisture content value obtained is strongly dependant on. Next, more investigation is necessary to manufacture high grade liquid organic fertiliser of commercial level based on their excellent quality and extended shelf life. Incomplete breakdown of carrier may yield organic harmful compounds that induce inhibition of plant development. More study on the use of molasses in liquid organic fertiliser should be done out in the field situation.

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APPENDICES

APPENDIX A

PARAMETERS MEASURED

A. SOIL PH

Table A.1. Measurement of soil pH of different treatments for sissoo spinach

Day	Formulation A	Formulation B	Formulation C	Commercial Fertilizer	Control
1	6.5	6.5	6.5	6.8	6.5
2	6.5	6.5	7.0	6.8	6.5
3	6.5	6.8	7.0	6.5	6.5
4	6.8	6.5	6.5	7.0	6.4
5	7.0	6.5	6.5	6.5	6.7
6	7.0	7.0	7.0	7.0	7.0
7	6.5	6.5	7.0	7.0	6.5
8	6.5	6.5	7.0	7.0	6.7
9	6.5	6.8	7.0	7.1	6.7
10	7.0	7.0	6.7	7.0	7.0
11	7.0	7.0	6.7	7.2	6.5
12	7.0	7.0	6.8	7.0	6.5
13	7.0	7.0	7.0	7.0	7.0
14	7.1	7.0	6.5	6.8	7.0
15	7.0	7.0	6.5	7.2	7.0
16	7.0	6.5	6.5	7.3	7.0
17	7.0	7.0	7.0	7.0	7.0
18	7.0	6.5	7.0	7.1	7.0
19	7.0	6.5	7.0	7.4	7.0
20	7.0	7.0	6.9	7.0	7.0
21	7.0	7.0	7.0	7.0	7.0
22	7.0	7.0	7.0	7.0	6.5
23	7.0	6.5	7.0	7.0	7.0
24	7.0	7.0	7.0	7.0	6.7
25	7.0	7.0	7.0	7.0	7.0
26	7.1	6.5	6.8	7.2	7.0
27	7.0	7.0	7.0	7.0	7.0
28	7.0	7.0	7.0	7.0	7.0

Table A.2. Measurement of soil pH of different treatments for rubber plant

Day	Formulation A	Formulation B	Formulation C	Commercial Fertilizer	Control
1	6.7	7.0	7.0	7.0	7.0
2	7.0	7.0	7.0	7.0	7.0
3	6.5	6.7	6.7	6.5	7.0
4	7.0	7.0	7.0.	7.0	7.0
5	7.0	7.0	7.0	7.0	7.0
6	7.0	6.9	7.0	7.0	7.0
7	7.0	6.5	6.5	6.5	6.5
8	6.5	6.5	6.5	6.5	6.5
9	7.0	7.0	6.5	7.0	6.5
10	7.0	7.0	7.0	7.0	7.0
11	7.0	7.0	7.0	7.0	7.0
12	6.7	7.0	7.0	6.5	7.0
13	7.0	6.5	7.0	6.5	7.0
14	7.0	7.0	7.0	6.5	7.0
15	7.0	7.0	7.0	7.0	6.5
16	6.5	6.5	7.0	7.0	7.0
17	6.5	7.0	6.5	7.0	7.0
18	7.0	7.0	7.0	7.0	7.0
19	7.0	7.0	7.0	7.0	7.0
20	7.0	7.0	7.0	6.5	6.5
21	7.0	7.0	6.5	7.0	7.0
22	6.8	6.5	7.0	7.0	7.0
23	7.0	6.5	7.0	7.0	7.0
24	6.8	7.0	7.0	7.0	7.0
25	7.0	7.0	6.5	7.0	6.8
26	7.0	7.0	6.7	6.5	7.0
27	7.0	7.0	7.0	7.0	7.0
28	7.0	7.0	7.0	7.0	7.0

B. SOIL TEMPERATURE

Table B.1. Measurement of soil temperature of different treatments for sissoo spinach

Day	Formulation A	Formulation B	Formulation C	Commercial Fertilizer	Control
1	28	29	28	28	29
2	27	27	27	27	27
3	29	29	28	28	29
4	28	28	29	29	29
5	30	29	29	29	30
6	27	27	28	27	27
7	28	28	29	28	29
8	29	30	30	29	29
9	30	29	30	30	30
10	30	30	30	30	30
11	28	29	28	28	28
12	28	29	29	29	29
13	27	27	27	28	27
14	26	27	27	27	26
15	25	26	25	25	25
16	27	27	28	27	28
17	27	27	28	28	26
18	26	26	28	29	28
19	30	30	28	29	30
20	29	29	29	29	29
21	29	28	28	29	29
22	30	30	29	29	29
23	29	29	29	28	28
24	30	30	30	30	30
25	29	29	29	29	29
26	28	29	29	28	29
27	29	29	29	29	29
28	28	29	29	28	29

Table B.2. Measurement of soil temperature of different treatments for rubber plant

Day	Formulation A	Formulation B	Formulation C	Commercial Fertilizer	Control
1	26	26	28	29	28
2	30	30	28	29	30
3	29	29	29	29	29
4	29	28	28	29	29
5	30	30	29	29	29
6	29	29	29	28	28
7	28	28	29	28	29
8	29	30	30	29	29
9	30	29	30	30	30
10	30	30	30	30	30
11	28	29	28	28	28
12	28	29	29	29	29
13	27	27	27	28	27
14	26	27	27	27	26
15	25	26	25	25	25
16	28	29	28	28	29
17	27	27	27	27	27
18	29	29	28	28	29
19	28	28	29	29	29
20	30	29	29	29	30
21	27	27	28	27	27
22	28	28	29	28	29
23	29	30	30	29	29
24	30	29	30	30	30
25	30	30	30	30	30
26	28	29	28	28	28
27	28	29	29	29	29
28	27	27	27	28	27

C. SOIL MOISTURE CONTENT

Table C.1. Measurement of soil moisture content of different treatments for sissoo spinach

Day	Formulation A	Formulation B	Formulation C	Commercial Fertilizer	Control
1	77	76	77	79	75
2	78	78	77	78	76
3	78	77	77	77	76
4	80	79	80	80	76
5	77	77	77	79	77
6	78	77	77	79	77
7	75	76	76	78	75
8	71	70	70	73	69
9	69	66	63	72	65
10	77	77	77	78	76
11	76	77	76	78	76
12	78	76	77	79	76
13	79	78	78	80	76
14	81	79	80	81	79
15	79	78	79	79	77
16	78	76	79	79	77
17	76	75	76	78	74
18	78	78	78	79	76
19	79	79	79	80	79
20	81	80	80	83	80
21	80	79	78	81	79
22	79	77	78	79	76
23	79	77	77	79	75
24	76	75	76	78	75
25	78	76	75	79	75
26	80	79	79	81	75
27	78	76	77	79	75
28	78	77	78	79	75

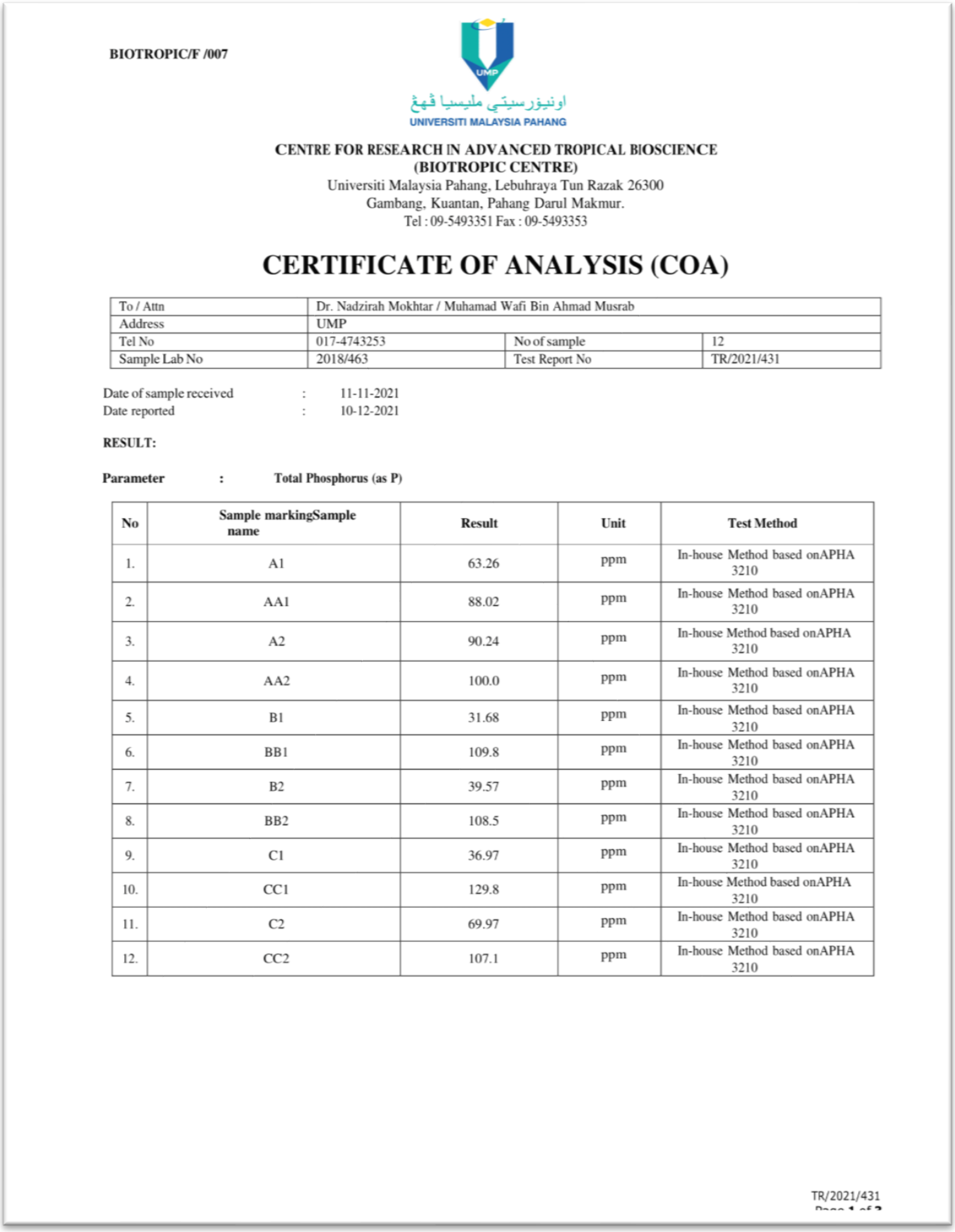
Table C.2. Measurement of moisture content of different treatments for rubber plant

Day	Formulation A	Formulation B	Formulation C	Commercial Fertilizer	Control
1	78	78	78	79	75
2	79	78	79	79	75
3	80	79	79	81	79
4	79	75	78	80	75
5	81	80	80	81	79
6	79	78	79	81	74
7	77	77	77	79	75
8	76	75	75	77	75
9	68	66	67	70	65
10	78	75	76	79	75
11	78	74	76	79	75
12	76	75	76	79	74
13	81	80	79	81	79
14	79	81	80	79	77
15	79	78	78	80	79
16	79	78	79	80	77
17	74	73	75	78	74
18	79	78	79	81	72
19	76	75	77	79	76
20	79	79	79	79	77
21	81	80	80	82	79
22	79	79	80	81	78
23	75	74	75	79	72
24	79	77	78	79	76
25	78	76	77	81	76
26	76	75	76	79	74
27	79	78	77	79	76
28	79	78	78	79	74

APPENDIX B

RESULT OF NPK CONTENT FROM CENTRAL LAB

A. THREE FORMULATION OF LIQUID ORGANIC FERTILIZER



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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/2021/431

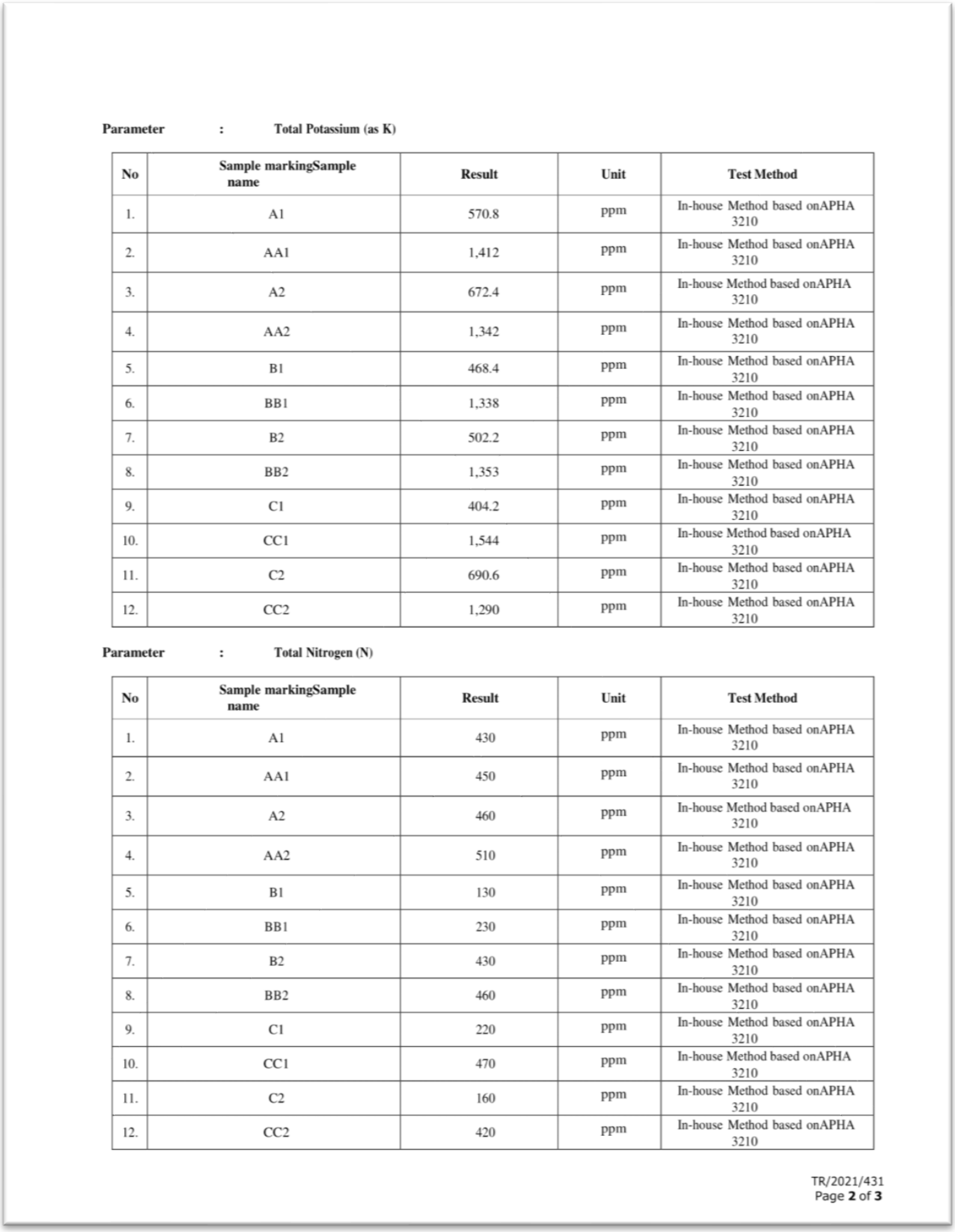
Date of sample received : 11-11-2021
Date reported : 10-12-2021

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

TR/2021/431



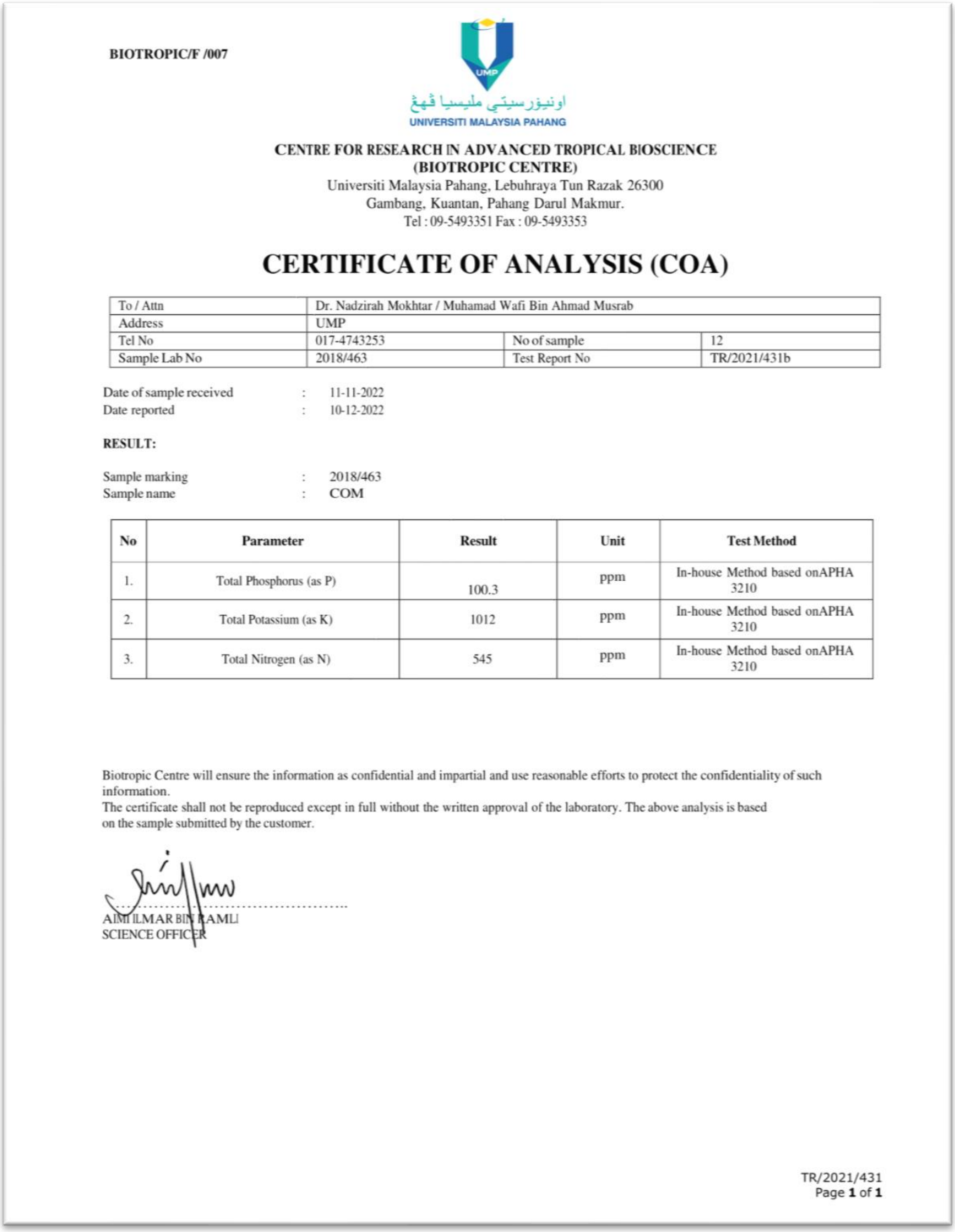
Parameter : **Total Potassium (as K)**

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

B. COMMERCIAL FERTILIZER



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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

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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 RAMLI
SCIENCE OFFICER

TR/2021/431
Page **1** of **1**

APPENDIX C

PRODUCTION OF LIQUID ORGANIC FERTILIZER

APPENDIX D

MEASURING PLANT GROWTH