THE OPTIMIZATION OF PLANTING MEDIA ENRICHED WITH BIOCHAR & BLACK SOLDIER FLY LARVAE (BSFL) FRASS

By
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A report submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Food Security) with Honours

Faculty of Agro Based Industry
Universiti Malaysia Kelantan

2022

DECLARATION

Except for quotations and summaries that have been properly acknowledged, I declare that the work in this thesis is all mine. The thesis has not been accepted for any degree and is not being submitted for any other degree at the same time.

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ACKNOWLEDGEMENT

Without the help of numerous people, this endeavor would not have been feasible. To begin, I'd want to express my gratitude to University Malaysia Kelantan, Jeli, for providing me with the opportunity to conduct my research in a calm and timely manner.

In addition, I'd want to express my gratitude to Encik Mohd bin Mahmud @ Mansor, my supervisor, and the lectures at Universiti Malaysia Kelantan for allowing me to work under their supervision. All of them have provided me with constructive criticism, support, direction, and helpful suggestions in order for me to accomplish this project. This thesis would not have been the same if it hadn't been for their continual interest and support.

My friends should also be thanked for their moral support and care. My heartfelt gratitude also goes out to everyone who have aided me in various ways, whether directly or indirectly, in the accomplishment of my project. Last but not least, I want to express my gratitude to my family for their unwavering help and encouragement.

The Optimization of Planting Media Enriched with Biochar & Black Soldier Fly Larvae (BSFL) Frass

ABSTRACT

In Malaysia, the organic food business is confronting many issues. The demand for organic food is increasing but the supply of organic food in the area is not keeping up. As a result, Malaysia continues to rely largely on imported organic food. Over fertilisation or lack of fertiliser are also one of the challenges that is faced by our organic farmer. In order to solve all these problems, planting media enriched with biochar and BSFL would be the best solution. The aim of this study was to identify the effects of different ratios of planting media enriched with biochar and Black soldier fly larvae (BSFL) frass on jimao choy. The growth parameters, pH and yield of the plants were observed in this research. There are seven treatments with three replications for each. Biochar and BSFL frass are used as treatment with different ratio. This study was used a completely randomized design (CRD) experimental design method. Besides, the NPK content in the biochar and frass also have been identified. In addition, ANOVA and Tukey's Honest Significant Difference test are used to test the hypotheses of this research. From the results obtained, it shows that planting media enriched with biochar and BSFL with the ratio 0 : 1 (T_1) and 2 : 1 (T_6) has a good plant development rate compared to other treatments in many things. Results show that frass has high nutrient content compared to biochar. This study employs organic agricultural techniques, which limit the use of chemical compounds such as herbicides, insecticides, and chemical fertilisers.

Keywords: BSFL frass, Biochar, NPK, ANOVA, Tukey's Honest Significant Difference

Pengoptimuman Media Penanaman Diperkaya dengan Biochar & Fras Larva Lalat Askar Hitam (BSFL)

ABSTRAK

Di Malaysia, perniagaan makanan organik menghadapi banyak isu. Permintaan terhadap makanan organik semakin meningkat tetapi bekalan makanan organik di kawasan itu tidak mencukupi. Akibatnya, Malaysia terus bergantung pada makanan organik yang diimport. Pembajaan berlebihan atau kekurangan baja juga merupakan salah satu cabaran yang dihadapi oleh petani organik kita. Untuk menyelesaikan semua masalah ini, media penanaman yang diperkaya dengan biochar dan fras larva lalat askar hitam akan menjadi penyelesaian terbaik. Matlamat kajian ini adalah untuk mengenal pasti kesan nisbah berbeza media tanaman yang diperkaya dengan biochar dan frass ke atas jimao choy. Parameter pertumbuhan, pH dan hasil tumbuhan diperhatikan dalam penyelidikan ini. Terdapat tujuh rawatan dengan tiga replikasi untuk setiap satu. Biochar dan BSFL frass digunakan sebagai rawatan dengan nisbah yang berbeza. Kajian ini menggunakan kaedah reka bentuk uji kaji rawak lengkap (CRD). Selain itu, kandungan NPK dalam biochar dan frass juga telah dikenal pasti. Selain itu, ujian ANOVA dan Ujian Perbezaan Ketara Jujur Tukey digunakan untuk menguji hipotesis penyelidikan ini. Daripada keputusan yang diperolehi menunjukkan media tanam yang diperkaya dengan biochar dan frass dengan nisbah 0 : 1 (T_1) dan 2 : 1 (T_6) mempunyai kadar perkembangan tumbuhan yang baik berbanding rawatan lain dalam banyak perkara. Keputusan menunjukkan bahawa frass mempunyai kandungan nutrien yang tinggi berbanding biochar. Kajian ini menggunakan teknik pertanian organik, yang mengehadkan penggunaan sebatian kimia seperti racun herba, racun serangga, dan baja kimia.

Kata kunci: Fras larva lalat askar hitam, Biochar, NPK, ANOVA, Perbezaan Ketara Jujur Tukey

LIST OF ABREVIATIONS

mL	Milliliter
g	Gram
T	Treatment
NPK	Nitrogen, Phosphorus, Potassium
B	Biochar
F	Frass
BSFL	Black soldier fly larvae
cm	Centimeter
Ca	Calcium
Zn	Zinc
Cu	Copper
EC	Electric conductivity
in	inch
CRD	Completely Randomized Design
ppm	part(s) per million
L	Liter
nm	Nanometer
T_1R_1	Treatment 1, Replication 1

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Agriculture has always been and will continue to be one of the most significant jobs because it is responsible for feeding and sustaining the world's population. Growing consumer awareness about concerns like food quality, environmental safety, and soil conservation has resulted in ~~a~~ significant growth in the implementation of sustainable agriculture practices in recent years. Sustainable agriculture has been defined as a collection of methods that conserve resources and the environment without jeopardising human needs, and one of its primary support has been the use of organic fertilisers such as biomass and animal manure (Tilman et al., 2002). Animal manure and biomass is a beneficial soil fertiliser because it contains a high concentration of macronutrients and micronutrients for crop growth and is a low-cost, ecologically acceptable alternative to mineral fertilisers.

Nowadays, agriculture activity has a lot of changes like planting crops using polybags, aquaculture, hydroponics, and many more. Since there is a lack of land for agriculture activity, geographical conditions such as hills and mountains, soil degradation and also soil infertility, we are adapting to modern agriculture. Instead of using soil, coco peat is used as planting media which is mixed with fertilisers. In the worldwide scenario, rising consumer awareness has boosted the demand for organic products. The organic supply, on the other hand, hasn't been able to keep up with demand. As a result, farmers are being pushed to switch to organic farming. Cropland nutrient management is a critical component of agricultural success. Organic fertilisers, such as the black soldier larvae fly, have therefore been a benefit to organic agriculture.

Coco peat has lately developed as a viable alternative for non-terrestrial plants, particularly in city settings where space constraints force people to look for other options (Siraj, 2018). The fibres that surround the coconut kernel typically make up one-third of the husk. The remaining two-thirds are high-nutrient-dense dusty contents. According to one article, one kilogram of coco peat can store and hold seven litres of water for several months. The great porosity of the coco peat substratum allows for good air circulation and rapid vegetative proliferation when planted with saplings. It's also high in nutrients including magnesium, nitrogen, phosphorus, potassium, zinc, and other key agricultural elements. Indoor gardeners consider coco peat to be a more natural alternative to soil. Coco peat hydroponic plants grow 50 % quicker than soil plants (Siraj, 2018). Because peat is high in nutrients, it decreases the need for fertilisers, herbicides, and pesticides. Because peat retains water for a long time, it reduces both the volume of water and the amount of labour required to water the plant. Because it is absorptive, it enables for more root aeration. When coco peat is made into pots and pans, it can be used as a plant container as well as a substitute for soil.

Nitrate leaching into coastal environments and rivers reduces the ability of common synthetic fertilisers to raise nitrate levels, causing eutrophication and polluting groundwater. Synthetic fertiliser use has also been linked to higher nitrous oxide emissions. A unique option is to combine biochar and BSFL frass as an organic fertiliser.

Pyrolysis, a regulated process that involves burning organic material from agriculture and forestry wastes, also known as biomass, produces biochar, a charcoal-like substance. Despite its resemblance to typical charcoal, biochar is manufactured using a unique method to reduce pollution and properly store carbon (Spears, 2018). Organic materials like wood chips, leaf litter, and dead plants are burned in a container with very little oxygen during pyrolysis. When the products are burned, they produce extremely few harmful pollutants (Spears, 2018). The organic material is converted to biochar during the pyrolysis process, a stable form of carbon that cannot easily escape into the atmosphere. The pyrolysis process produces energy or heat that can be stored and used as a sustainable energy source. Biochar is significantly more effective than other types of charcoal at turning carbon into a stable form, and it is also far safer. Biochar is black, very porous, lightweight, fine-grained, and has a huge surface area in terms of physical attributes. Carbon accounts for over 70% of its mass, with nitrogen, hydrogen, and oxygen, among other components, accounting for the remainder. Soil erosion is a major challenge in agriculture around the world. As a remedy to this expanding problem, researchers proposed utilising biochar to restore the condition of damaged soils. Biochar can assist enhance soil quality in a number of ways, including strengthening soil structure, boosting water retention and aggregation, lowering soil acidity, increasing microbial activity, and so on.

The only plant-digestible source of chitin is found in the solid faeces of insect larvae, which is known as Black Soldier Fly Larvae (BSFL) or Hermetia illucens. This chitin produces antimicrobial peptides that act as a protective barrier when exposed to environmental stress (Sistrunk, 2016). Frass also contains bacteria that contribute to the nitrogen cycle by nitrifying and nitrogen-fixing, as well as microorganisms that assist plants to absorb nitrogen (Behie & Bidochka, 2013). It has been proven that sites with far more artificial fertilizers produce more greenhouse gases, such as nitrous oxide, whereas BSFL frass can store carbon and nitrogen in the soil (Hawkinson, 2005). (Lovett and colleagues, 2002). By allowing microbes to fix nitrogen, BSFL frass reduces nitrogen depletion in the atmosphere and groundwater pollution (Lovett et al., 2002). Because plants can't absorb nitrogen straight from the air, bacteria must fix it before it can be absorbed by the plants. Bacillus and Pseudomonas aid in the fixation of atmospheric bacteria in frass, while other nitrifying bacteria make nitrogen available to plants in the soil for photosynthesis (Zahn, 2017).

1.2 Problem Statement

Awareness of consuming organic food has been raising among consumers (Mohamad et al., 2014). Hence, the demand for organic food also has been an increase. In Malaysia, the organic food business is confronting a number of issues. Although the demand for organic food is increasing, the supply of organic products in the local area is not keeping up. Aside from the inconsistency of supply, the range of organic food available in the area is also limited. As a result, Malaysia continues to rely largely on imported organic food, particularly from the United States, Japan, Australia, New Zealand, and China (Dardak et al., 2009). Besides, Inadequate fertiliser management skill has resulted in imbalanced fertiliser application (Aryal et al., 2021). To increase plant growth and output, people over-fertilize the soil. It's possible that this will create more damage than good. Indoor plants can also be hampered by too much, too little, or the wrong type of fertiliser, which can cause growth and fruit production to halt or stop. Inappropriate and unbalanced nutrient addition not only affects nutrient usage efficiency and profitability, but it also raises environmental concerns associated with wasted nutrients being lost through emissions, leaching, or run-off (Aryal et al., 2021). Organic fertiliser should be used in correct amount in order to have a healthy growing of a plant or vegetables.

To address all of these issues, planting media enriched with biochar and BSFL will be the most effective approach. This planting media will be made using a variety of biochar + frass fertiliser ratios and will be used to evaluate the growth and yield of the plants throughout the study. The biochar and BSFL enriched planting media do not require pesticides or fertilisers because they already contain the majority of the nutrients required for plant growth.

1.3 Objectives

The general purpose of this research is to create an organic planting media enhanced with biochar and BSFL. The following are the specifics of this research:

1. To evaluate the effect of the planting media enriched with biochar and BSFL frass on the growth and yield of Jimao choy plant.
2. To analyse nitrogen, phosphorus and potassium content in different ratio of planting media enriched with biochar and BSFL.
3. To assess nitrogen, phosphorus and potassium content in biochar and BSFL.

1.4 Hypothesis Statement

In response to the study questions, a null and alternative hypothesis have been developed, as shown below. These hypotheses can be tested using the following criteria:

H_0: Planting media with different ratios of biochar and BSFL frass not affect plant growth of Jimao choy.

H_1: Planting media with different ratios of biochar and BSFL frass will affect plant growth of Jimao choy.

1.5 Scope of the study

This study included the preparation of planting media which consist of biochar and BSFL frass in the different ratios that was tested on 'Jimao choy' plant. Instead of soil, coco peat will be used as a media and plant Jimao choy in poly bags. Throughout this research, the height of the plant, number of leaves, and yield were observed to compare the best media ratio mixes. Besides, the nitrogen, phosphorus and potassium (NPK) content in each different ratio of media was identified by using Kjeldahl method, colour development, followed by taking the absorbance reading by using a spectrophotometer and an apparatus, Horiba LAQUAtwin potassium ion meter, was used to determine the potassium content. This study was conducted at Agro Techno Park (ATP), and also at Chemistry Laboratory, Universiti Malaysia Kelantan, Jeli Campus.

1.6 Significance of the study

This study is essential to develop a good planting medium that can be very beneficial for the general population, government, industries farmers and researchers. Most of the people are aware of the presence and the use of the organic fertilisers. However, not everyone knows the best ratio mixes of organic fertiliser, that is efficient for plant growth. From this research, general population and farmer are able to get an efficient planting media ratio, which can be used for plantation. Besides, those who are staying in urban, also can use this optimized organic fertilizer to grow fresh and organic vegetables or fruits by their own. Here, at urban it is difficult to get an organic vegetables or fruits. Most of the farmers are using pesticides, herbicides, and chemical fertilisers to increase the growth rate of the plant. Perhaps, the farmers can increase their income by using this planting media since it has a potential in increasing the yield of a crop. The advantages that may get by government and industries are increases profit in sustainable agriculture since this planting media will increase the yield and input does not cost much. Besides expand the profit by collaborating with international countries in agriculture sectors. This research also can be used as a reference for more sophisticated researchers.

CHAPTER 2

LITERATURE REVIEW

2.1 Organic Agriculture

With customers' increased preference for organically grown food for health reasons, the demand for animal waste is likely to skyrocket. Organic farming has the potential to thrive in Malaysia. Because of health concerns, there is a growing preference for organically produced food. Organic farming has a high labour requirement, which drives up production costs (Ahmad, 2001). The Department of Agriculture (DOA) has taken the lead in developing a draught Malaysian Standard - Guidelines for the Production, Processing, Labelling, and Marketing of Organically Produced Food (Ahmad, 2001). In many ways, modern farming systems undermine community well-being (Schmid et al., 2011). Huge areas of natural habitats, including their ecosystem services, have been destroyed; plant protection measures have resulted in human health issues, and they are responsible for approximately 30% of greenhouse gas emissions (Sachs et al., 2010). Organic farming, as an alternative to conventional agriculture, aims to reduce its environmental impact by using crop rotation, pathogen-resistant cultivars, limited amounts of chemical pesticides, and organic manure instead of synthetic fertilisers.

2.2 Black Soldier Fly Larvae (BSFL)

The sole plant-digestible source of chitin is BSFL (Hermetia illucens), which is found in the solid faeces of insect larvae. This chitin produces antimicrobial peptides that act as a protective barrier when exposed to environmental stress (Sistrunk, 2016). Frass also contains bacteria that contribute to the nitrogen cycle by nitrifying and nitrogen-fixing, as well as microorganisms that assist plants absorb nitrogen (Behie & Bidochka, 2013). BSFL frass also minimises nitrogen depletion in the atmosphere and groundwater pollution by allowing microbes to fix nitrogen (Lovett et al., 2002). Because plants cannot absorb nitrogen from the atmosphere directly, bacteria must fix the nitrogen before it can be absorbed by the plants. Nitrifying bacteria convert ammoniacal nitrogen to nitrate nitrogen, allowing plants to absorb more nitrogen through their roots (Alattar et al., 2016).

Alattar et al. (2016) conducted a study on the effects of microaerobic fermentation and BSFL food scrap processing residues on maize plant growth (Zea mays). Kitchen garbage provided all of the organic components used in the corn plant studies. Fruits, vegetables, bread, coffee grounds, rice, cereals, and dairy goods were among the items that were thrown away. Except for BSFL, both treatments and controls increased 30 cm in height on average over the first three weeks of the study (Alattar et al., 2016). BSFL therapies slowed development even at this early stage, with an average of 11 cm after three weeks. Plant growth may be hindered when the BSFL soil ratio is 1:2 for a variety of reasons, including loss of some primary nutrients, poor soil drainage resulting in anaerobiosis, or phytotoxic components. The high ammonium concentrations in BSFL residues, as well as the limited porosity of the residues, were used to hypothesise these effects. Despite substantial studies into the conversion of organic waste into BSFL biomass for animal feed, no studies on the utilisation of BSFL solid residues from food scrap feedstocks as soil supplements have been conducted (Diener et al. 2011; Makkar et al. 2014). More research on the stabilisation of BSFL solid residue for application as a soil amendment is required.

Choi & Hassanzadeh (2019) published a study named "BSFL Frass: A Novel Biofertilizer For Improving Plant Health While Minimizing Environmental Impact." This study reveals that BSFL frass does not spread illness but rather guards against it, meaning that regularly applying frass to soil can assist to avoid fungal disease caused by pathogens like Rhizoctonia, Fusarium, and Pythium. According to the findings, no R. solani or F. oxysporum developed in any of the two disease transmission trials, showing that the disease caused by the fungi was metabolised by the larvae and turned into safer compounds for the ecosystem. As a result, BSFL frass can be used as an organic fertiliser without polluting the environment. The pH ranges in frass treatments were also more appropriate, which is important for the formation of beneficial bacterial populations in frass and plant growth (Perry, 2003). The pH results correlate with the high amounts of nitrate in the frass treatment groups because a higher concentration of nitrifying and nitrogen-fixing bacteria permits the plant to consume more nitrogen.

2.3 Biochar

Biochar is a carbon-rich organic substance, an organic amendment, and a by-product of biomass pyrolysis at high temperatures and low oxygen levels (Rawat et al., 2019). Pyrolysis is a process for producing biochar that includes heating biomass in the absence or near absence of oxygen, producing oil and gas as byproducts (Hofstrand, 2009). Biochar improves the fertility and condition of the soil (Hofstrand, 2009; Zhang et al., 2020). In terms of physical properties, biochar is black, very porous, lightweight, fine-grained, and has a large surface area. Carbon accounts for almost 70% of its total mass (Spears, 2018). The remaining percentage is made up of nitrogen, hydrogen, and oxygen, among other elements. Biochar's chemical makeup changes based on the feedstocks used and the heating processes used.

Biochar supports the Earth's soil resource by increasing productivity and crop yields, lowering soil acidity and many more. Because it contains organic matter and nutrients, biochar boosted soil pH, electric conductivity (EC), organic carbon, total nitrogen, useable phosphorus, and cation-exchange capacity (Chan et al., 2007; Liang et al. 2006; Rawat et al., 2019). Biochar boosted leaf nutritional content while decreased nutrient runoff in a sandy soil test, according to researchers (Solaiman et al., 2020). Poultry litter biochar in conjunction with fertilisers and compound poultry manure (CPM) supplied healthy fruit and enhanced cucumber development and production by enhancing soil quality, nutrient concentration in soil, and water-holding ability, and therefore making the soil favourable to better plant growth. The rise in nutrient concentrations in leaves can be directly affected by plant nutrient uptake due to the nutrient content of biochar, its release properties, availability of nutrients, and increased absorption of nutrients (Lehmann et al., 2003; Pandian et al., 2016). Mulcahy et al. (2013) discovered that tomato growth, yield, and nutrient concentrations improved considerably in sandy soils modified with biochar. As previously indicated, adding more biochar, with or without organic and inorganic fertilisers, enhanced plant absorption of P, K, Ca, Zn, and Cu, as well as fertiliser performance, and hence reduced nutrient leaching from soil (Lehmann et al., 2006).

2.4 Cocopeat

Cocopeat is a multi-purpose growth medium made from coconut husk. Sand and other impurities such as animal and plant waste are removed from the fibrous coconut husk after it has been pre-washed, machine dried, and sieved. Cocopeat is a good substitute for peat moss and rock wool (Nature's Bounty PLC, n.d.). It is an ideal growing medium for plant crops due to its high water holding capacity and air-filled porosity. There are no soil-borne infections or weeds, therefore it's completely sustainable and environmentally friendly. It has a pH range of 5.7–6.5 and an EC of less than 1 mS/cm, making it perfect for plant growth. Coco coir may be reused because it is so environmentally friendly. After a short rinse and strain, it will operate properly again.

When compared to soil, coco peat absorbs far more water and gradually releases it to plant roots (Grant, 2019). Using coco peat as a planting medium has numerous advantages. It absorbs a lot of water. According to reports, a kilogramme of cocopeat can absorb and store seven litres of water for several months (Siraj, 2018). The great porosity of the coco peat substratum allows for good air circulation and rapid vegetative proliferation when planted with saplings. It's also high in nitrogen, potassium, phosphorus, magnesium, zinc, and other farm-related nutrients (Siraj, 2018). Cocopeat is also utilised by home gardeners as a sustainable alternative to soil. Hydroponic plants cultivated in cocopeat grow 50% quicker than those planted in soil. Because peat has enough nutrients on its own, it eliminates the need for fertilisers, herbicides, and pesticides. Because peat retains water for a long time, it reduces the amount of water and effort required to water the plant. Coco peat, when used instead of peat moss in the culture of cape gooseberry seedlings, increases root volume, according to Daz et al. (2010). Because it is porous, it provides for improved root aeration.

CHAPTER 3

METHODOLOGY

3.1 Material and Apparatus

3.1.1 Material

The planting media was made by using all natural and organic fertilisers. The soil was replaced with coco peat in polybags. First of all, the Jimao choy seeds, which were bought from alice4869 shop (shopee), were planted in agriculture soil for seed germination, and then it was transferred to a polybag. Jimao choy plant was used in this research to study ~~about~~ the effect of the optimised planting media enriched with biochar and BSFL frass on the growth parameter and yield of a plant that is planted with different ratios of fertilisers. Biovae store sold black soldier fly larvae (organic fertiliser and soil amendment made from herbivore insect faeces) (shopee). Cocos nucifera is a type of coconut (Coco peat). Biochar is a type of biochar that is (carbon-rich organic material, an organic amendment, and a by-product generated by pyrolysis of biomass at high temperatures and low oxygen levels). Agriculture soil.

3.1.2 Apparatus

5 in x 7 in size of poly bag (40 bags), digital analytical scale (1 unit), measuring tape (1 unit), plant tags (40 units), hand gloves (1 unit), watering can (1 unit).

3.2 Method

3.2.1 Preparation of germination bed

The agricultural soil was filled in the two egg cartons instead of seedling trays. Then, the egg cartons were watered using a pressure sprayer bottle. After that, the Jimao choy seed was sown in the two trays. Make sure there are two or three seeds in each small pot. The seeds need to be watered every other day to keep moist. The seedlings were ready to transfer to the poly bags that consist of different ratios of media, after true leaves form.

3.2.2 Preparation of planting media

Planting media consisting BSFL frass and biochar were made in various ratios, as shown in Table 1. Coco peat was used to replace the soil. To test the effect of optimised planting media enriched with biochar and BSFL frass on the growth and yield of a plant planted with different ratios of planting medium and it will be planted with a short mature period plant, Jimao choy. Different ratios of biochar and BSFL frass which was mixed with coco peat were prepared to get a total of 95 g of optimised planting media. The weight of coco peat was be made constant at 85 g and another 10 g will be a ration variation of biochar and BSFL. The compressed coco peat was immersed in water for 30 minutes to rehydrate before being put in the poly bags. 3 replicates were be used for each treatment, in this study. Do not combine any fertilizers which act as the control variable, T_0. After the media were mixed according to the ratio, the media was transferred into polybags for planting. At the same time, the nitrogen, phosphorus, and potassium (NPK) content of each planting media with different ratios of biochar and BSFL were identified by using Kjeldahl method to analyse nitrogen content, Dilute double acid, Mehlich 1 method which is then the prepared reagents will use for colour development method to analyse phosphorus content using a spectrophotometer and for potassium an apparatus was used which was Horiba LAQUAtwin Potassium ion meter.

Table 3.1: The various treatments of planting media

Treatment number	**Treatment**		
	Coco peat	Biochar	BSFL frass
T_0	85 g	-	-
T_1 (0 Biochar : 1 BSFL frass)	85 g	-	10 g
T_2 (1 Biochar : 1 BSFL frass)	85 g	5 g	5 g
T_3 (1 Biochar : 2 BSFL frass)	85 g	3.3 g	6.6 g
T_4 (1 Biochar : 3 BSFL frass)	85 g	2.5 g	7.5 g
T_5 (1 Biochar : 0 BSFL frass)	85 g	10 g	-
T_6 2 Biochar : 1 BSFL frass	85 g	6.6 g	3.3 g
T_7 (3 Biochar : 1 BSFL frass)	85 g	7.5 g	2.5 g

3.2.3 Preparation of sample

The rain-shelter house at ATP 1 was cleaned and made sure there were no holes or damages in the rain-shelter house. After the planting media were prepared, the germinated Jimao choy seeds were transferred in a polybag about 1/2 inches deep in the planting media, that were prepared with different ratios. After planting, it is very important to water the plant and check pH value of the soil every other day. This study was used a completely randomized design (CRD) experimental design method.

Table 3.2: The Completely Randomized Design (CRD)

T_2R_2	T_4R1	T_7R_3
T_5R_1	T_3R_2	T_0R_2
T_7R_2	T_5R_2	T_1R_3
T_0R_1	T_4R_3	T_3R_3
T_5R_3	T_6R_1	T_2R_1
T_1R_1	T_6R_3	T_4R_2
T_6R_2	T_1R_2	T_3R_1
T_0R3	T_7R_1	T_2R_3

3.2.4 Parameters tested

In this study, four parameters were tested, which were the height of the plant, pH, number of leaves, fresh weight, and dry weight. These parameters should be measured throughout this study to analyse the effect of biochar and BSFL on plant growth. The fresh weight of the plants for each treatment was measured immediately after harvesting. This is because plants have high water content and waiting to weigh them may cause some drying and thus produce inaccurate data. Furthermore, using dry weight as a measure of plant growth would be more valid because plants have ~~a~~ high water content and the amount of water in a plant depends on the amount of water in its environment. So, when it was dried, the water content in the plant's cells would evaporate, and we could get reliable data to observe the effects of different ratios of biochar and BSFL frass on the jimao choy. Every other day, the height of the plants was measured using a measuring tape in centimetres. This parameter is very important to measure since it will show a significant difference in the effect of different ratios of organic fertilizers, which were biochar and BSFL frass. Besides, the pH of the soil in each treatment was also measured using the soil pH metre to indicate the soil condition.

Moreover, the nitrogen (N), phosphorus (P), and potassium (K) content in the soil were also analysed using three different methods. The N, P and K content in biochar and BSFL data were represented as before planting, while treatment 1 (which was only mixed with BSFL frass) and treatment 5 (which was only mixed with biochar) were represented as after planting. From this, we could differentiate the amounts of N, P, and K that were absorbed or used by the crop. These three nutrients are very essential for plant growth. Any one of these deficiencies would cause the crop to wilt, turn yellowish, and eventually die.

3.3 Laboratory Analysis Method

3.3.1 NPK analyzing in soil samples

The plant that was used this survey is jimao choy, since it was a fast-growing and could be harvested quickly. The nitrogen, phosphorus, and potassium content were analyzed using three different methods; Kjeldahl method to analyse nitrogen content, Dilute double acid, Mehlich 1 method which is then the prepared Reagents will used for colour development method to analyse phosphorus content using a spectrophotometer and for potassium an apparatus was used which was Horiba LAQUAtwin Potassium ion meter.

3.3.2 Method analysing nitrogen content in the soil

To measure nitrogen content in soil samples, the Kjeldahl method was used in this research. First of all, two tablets of Kjeldahl catalyst were added inside the Kjeldahl digestion tube. Then, 20 mL of distilled water, followed by 12 mL of sulphuric acid, were added into the tube. The same tube was then filled with 1 g of soil sample. The sample was taken after the soil from each polybag was mixed thoroughly. Next, the 30 samples were heated at 400 ^{o}C for 4 hours until the samples turned a greenish blue colour. Meanwhile, the boric acid and sodium hydroxide (40%) were prepared. To prepare 450 mL of the boric acid solution, 18 g of boric acid (powder form) and 300 mL of water were added to a beaker. Then, it was stirred on a hot plate at 100 ^{o}C. To prepare sodium hydroxide, 40% and 400 g of sodium hydroxide (powder form) were diluted with 1000 mL of distilled water.

The samples were cooled once they had turned greenish-blue. At the same time, 4.5 mL of bromocresol green and 3.15 mL of methyl red were added to the boric acid solution. Then, 30 mL of the boric acid indicator solution was added into a conical flask and kept aside to be used for distillation. Upon cooling, 80 mL of distilled water, followed by sodium hydroxide, were added into the Kjeldahl digestion tube. Moreover, the samples underwent a distillation process. The samples were distilled until the boric acid indicator solution turned purple to green in colour. The last step was titration, where the samples were titrated with 0.01 M of hydrochloric acid until the colour changed from green to purple. The N content was taken from the acid used from titration.

3.3.3 Preparation of Plant Tissues for Analysis of Nutrients (P & K)

3.3.3.1 Extraction

The single dry ashing method was carried out to determine the organic material in the soil sample. First of all, the soil samples (the sample was taken after the soil from each polybag mixed thoroughly) from all the treatments were taken, and 1 g of each sample was placed in the crucible. The crucible containing the samples was then placed in a muffle furnace and ashed at 520 ^{o}C for 6 hours. After ashing, 2-3 drops of distilled water were added into the crucible, followed by 2 mL of concentrated hydrochloric acid. The sample, was then, evaporated to dryness in a fume chamber using a hot plate. Once the samples were evaporated completely dry, the hot plate was turned off. The samples were treated with 20% nitric acid, HNO_3 (20% HNO_3 = 200 mL of HNO_3 in 1 L of distilled water), and allowed to cool on the warm hot plate. After that, the samples in the crucible were filtered into a 100 mL volumetric flask and made up to 100 mL. This solution is then used to identify potassium and phosphorus content in the samples.

3.3.4 Method analysing phosphorus content in the soil

3.3.4.1 Dilute Double Acid, Mehlich 1 Method (Mehlich, 1953)

Mehlich 1 method was used in this research to prepare Reagent A and Reagent B, where it will be used to identified phosphorus content in the soil sample. To prepare Reagent A, 6 g of ammonium molybdate, $(NH_4)_6MO_7O_{24}$ was dissolved with deionized distilled water (≈ 100 mL). In a different beaker, 0.1454 g of potassium antimonyl tartrate, $K(SbO)C_4H_4O_6$ was weighted and dissolved with deionized distilled water (≈ 50 mL). 500 mL of deionized distilled water, followed by 74 mL of sulfuric acid, H_2SO_4 were added into a 1 L volumetric flask. Next, ammonium molybdate, $(NH_4)_6MO_7O_{24}$ was added and allowed it to cool down at room temperature for approximately 1 hour. Then, potassium antimonyl tartrate, $K(SbO)C_4H_4O_6$ was added and make up to 1 L with deionized distilled water. This Reagent was mixed thoroughly and left overnight. The next day, Reagent B was prepared using Reagent A. To prepare Reagent B, 2.64 g of ascorbic acid was weighed and 500 mL of Reagent A was added to it. This Reagent is then used to determine phosphorus content by using colour development method.

3.3.4.2 Colour Development

In a 50 mL volumetric flask, 8 mL of reagent B was added. Then, 1 mL of the soil extract was pipetted into the volumetric flask, followed by a few drops of distilled water. When the sky-blue colour was not formed, another 1 mL of the soil extract was pipetted into the volumetric flask and the volume was noted down for calculation purposes. After the blue colour developed, the solution was pipetted into a cuvette and the absorbance was measured with UV-VIS spectrophotometer with a wavelength of 882 nm.

3.3.5 Method for analysing potassium content in the soil

Once the samples were extracted after ashing, the solution was used to determine potassium content by using an apparatus that was designed by Horiba LAQUAtwin Potassium ion meter. The apparatus was calibrated using two standard solutions, which were 150 ppm and 2000 ppm. After calibration, 2-3 drops of the soil extraction solution were added inside the apparatus, and the readings for all samples were recorded.

3.4 Statistical Analysis

3.4.1 Anova & Tukey's Honest Significant Difference test

The single factor, variation, is the focus of this study and its growth parameter and pH value analysis. As a result, the finest way for statistical analysis to detect the significant value and difference between means is ANOVA and Tukey's Honest Significant Difference test. The analysis of variance (ANOVA) is a statistical approach for dividing the observed aggregate variability of a data set into two parts: systematic and random variables (Kenton, 2021). Systemic issues, on the other hand, have a statistical impact on the data gathering. The ANOVA test is used in regression analysis to analyse the impact of independent factors on the dependent variable. Besides, dividing the absolute value of the difference between pairs of means which was got from the one-way ANOVA test's standard error of the mean (SE). This method is known as Tukey's Honest Significant Difference test.

Rather than comparing pairs of values, Tukey's Honest Significant Difference test compares differences between means of values. The Tukey test value is computed by dividing the absolute value of the difference between two means by the one-way ANOVA test's standard error of the mean (SE) (Kevin, 2018). The SE is calculated by dividing the square variance by the sample size. The Tukey test is a post hoc test, meaning it compares variables after data has been collected (Kevin, 2018). In contrast, an a priori test makes these comparisons ahead of time.

CHAPTER 4

RESULTS AND DISCUSSSION

4.1 Results

4.1.1 Plant Height

The height of the plant is very important in any agriculture-based research to understand the effect of variables on it. In this research, each plant's height in each treatment and control variables were measured to study the effects of the biochar and BSFL. The fertilisers, biochar, and BSFL, were applied once after transplantation for each sample, except for control plants. Besides, the height of the plants was measured until the day of harvesting. T_5 recorded the lowest height when compared to control (T_0) and other treatments. While T_6 recorded the highest value compared to control plants and treatment plants, which was 15.1 cm. The T_2 and T_7 plants, on the other hand, showed a slight difference from the T_6 plants. We can see that only T_5 grows very slowly compared to T_0. The BSFL treatments resulted in a great difference when

compared to the control plants and the other treatments. The biochar and BSFL frass with a ratio of 2:1 had the fastest and highest growth rate of all the samples, which was T_6R_1 = 15.2, T_6R_2= 13.5, and T_6R_3 = 16.5. Besides, the mean height of T_6 was 15.07 cm. (Refer to appendices) According to ANOVA, the planting media that contain biochar and BSFL frass with a different ratio have a significant effect on the height of the plants (Table 4.20 appendices).

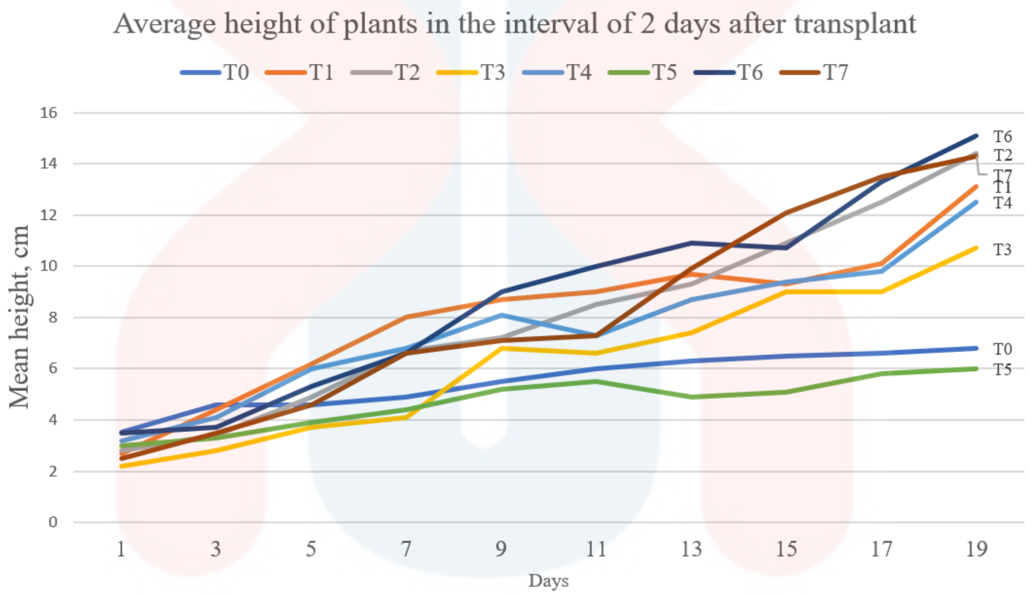

Figure 4.1 : The mean height of plants for each treatments.

Table 4.1 : The mean height of plants for each treatments in homogeneous subsets.

Height, cm					
	Treatment	N	Subset for alpha = 0.05		
			1	2	3
Tukey HSD[a]	T5	3	5.967		
	T0	3	6.800	6.800	
	T3	3	10.667	10.667	10.667
	T4	3		12.467	12.467
	T1	3			13.067
	T7	3			14.267
	T2	3			14.433
	T6	3			15.067

	Sig.		.222	.090	.286
Means for groups in homogeneous subsets are displayed.					
a. Uses Harmonic Mean Sample Size = 3.000.					

4.1.2 Plant Weight

As with plant height, a plant's weight also plays a major role in determining the effects of biochar and BSFL frass with different ratios on the growth parameters. There were significant weight variations between the two treatments. T_1 has the greatest plant fresh weight of 17.24 g, followed by the T_7, which has 11.43 g, the T_2, which has 13 g, and the T_6, which has 10.93 g. Fresh weight for other treatments has a weight of 10 g and below. The fresh weight of T_4 and T_3 was 10.57 g and 10.20 g, respectively. While the fresh weight for T_0 was 0.33 g, T_5 has the lowest fresh weight compared to the control plant and other treatments, which was 0.28 g. For dry weight, T_1 has the greatest value which was 0.0343 g, followed by T_2, which has 1.0071 g, the T_7, which has 0.9767 g, and T_6, which has 0.9188 g. Moreover, the dry weight for T_4, T_3, T_5, and T_0 were 0.7536 g, 0.7089 g, 0.0365 g, and 0.0343 g respectively. The treatment that obtain the lowest fresh weight was T_5 while for dry weight was T_0. According to ANOVA, the planting media that contain biochar and BSFL frass with a different ratio have a significant effect on the weight of the plants (Table 4.21 & 4.22 appendices).

Table 4.2: The fresh and dry weight of plant for each treatment

Treatment	Fresh Weight, g	Dry Weight, g
T_0R_1	0.61	0.0615
T_0R_2	0.1	0.0114
T_0R_3	0.2	0.0299
T_1R_1	22.7	1.4523
T_1R_2	15.81	1.021
T_1R_3	13.2	0.9552
T_2R_1	12.7	0.9396
T_2R_2	16.9	1.2274
T_2R_3	9.4	0.8543
T_3R_1	19.8	1.3808
T_3R_2	1.7	0.1185
T_3R_3	9.1	0.6275
T_4R_1	12.9	0.866
T_4R_2	6.8	0.4471
T_4R_3	12	0.9477
T_5R_1	0.45	0.0541
T_5R_2	0.32	0.042
T_5R_3	0.08	0.0135
T_6R_1	10.9	1.9875
T_6R_2	10	0.842
T_6R_3	11.9	0.9268
T_7R_1	13.7	1.0729

T_7R_2	10.3	1.0152
T_7R_3	10.3	0.8421

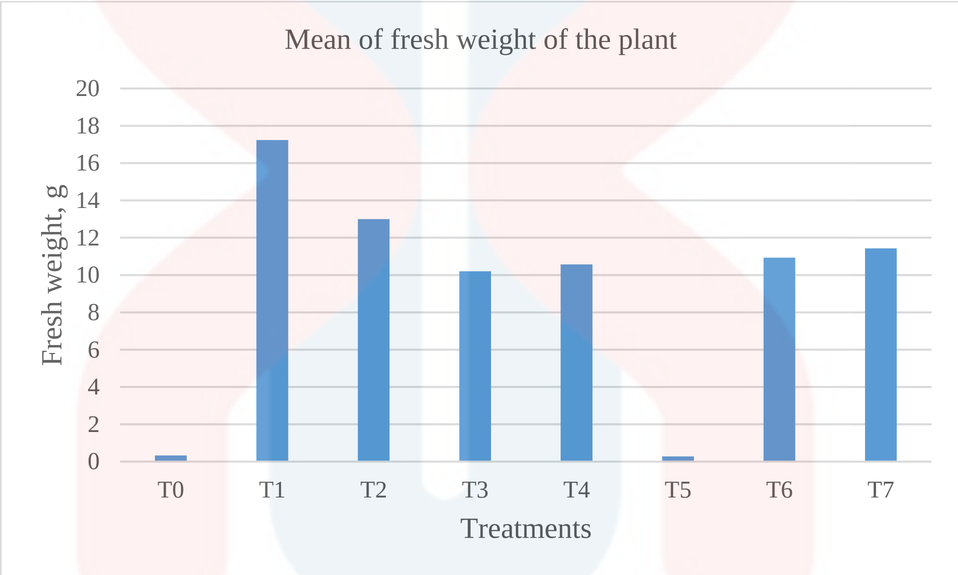

Figure 4.2 : The mean fresh weight of plants for each treatments.

Table 4.3: The mean fresh weight of plants for each treatment in homogeneous subsets.

Weight in g				
	Treatment	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a]	T5	3	.2833	
	T0	3	.3033	
	T3	3	10.2000	10.2000
	T4	3	10.5667	10.5667
	T6	3	10.9333	10.9333
	T7	3	11.4333	11.4333
	T2	3		13.0000

	T1	3		17.2367
	Sig.		.067	.463
Means for groups in homogeneous subsets are displayed.				
a. Uses Harmonic Mean Sample Size = 3.000.				

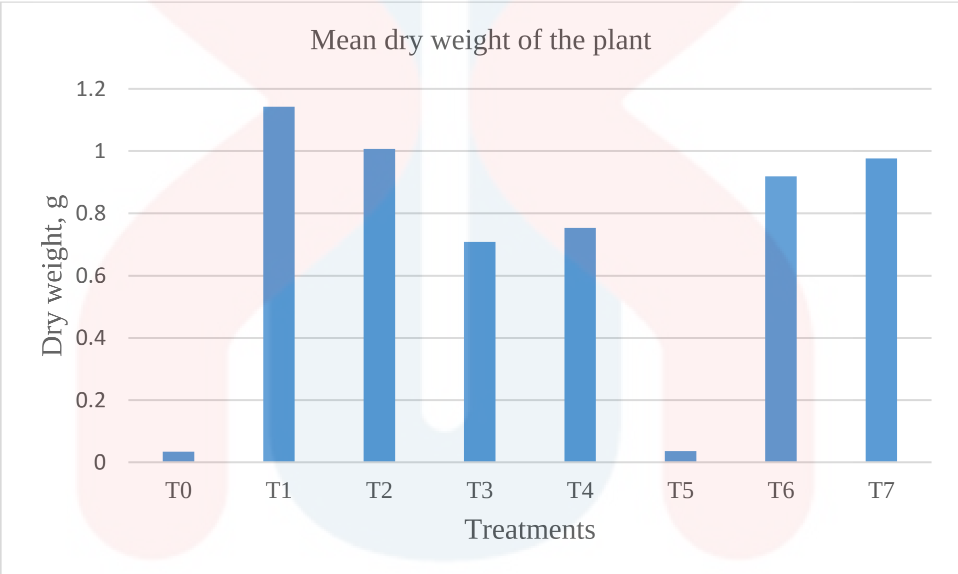

Figure 4.3 : The mean dry weight of plants for each treatments.

Table 4.4 : The mean dry weight of plants for each treatments in homogeneous subsets.

Dry Weight, g

	Treatement	N	Subset for alpha = 0.05 1	2
Tukey HSD[a]	T0	3	.034267	
	T5	3	.036533	
	T3	3	.708933	.708933
	T4	3	.753600	.753600
	T7	3	.976733	.976733
	T2	3	1.007100	1.007100
	T1	3		1.142833

	T6	3		1.252100
	Sig.		.061	.586

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

4.1.3 Number of Leaves

According to ANOVA, the application of different ratios of biochar and BSFL had a significant effect on the number of leaves (Table 4.23 appendices). The highest mean number of leaves (6.67) was found in T_6, while the lowest number (3.33) was found in T_5. Other treatments' mean values do not differ much when compared to T_5 and T_6. Although biochar and BSFL frass were applied in different ratios to all the treatments, the mean value for T_1, T_2 and T_7 was the same, which was 5.00. Besides, the mean number of leaves for T_3 and T_4 was 5.67 and 4.33, respectively. T_0 record the second-lowest number, which was 3.67.

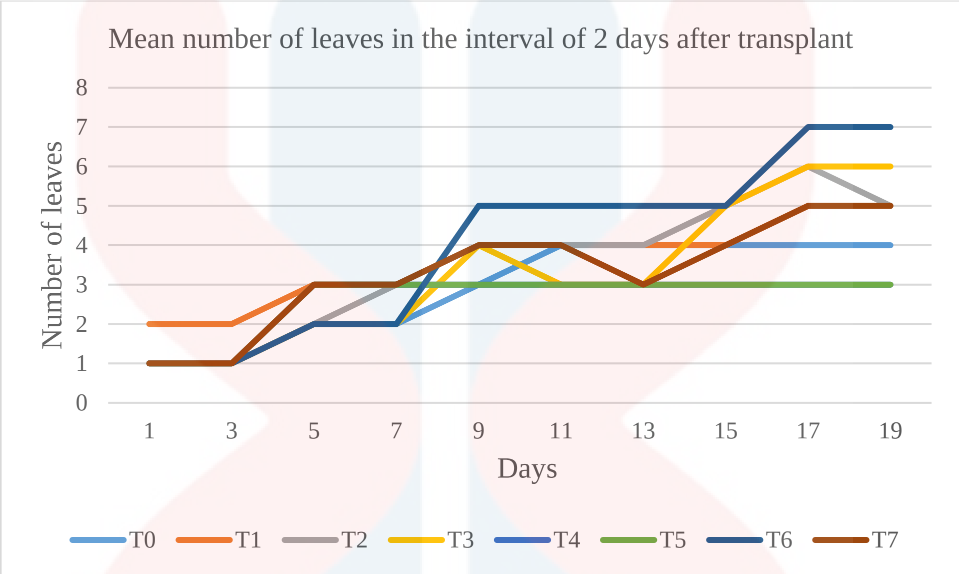

Figure 4.4 : The mean number of leaves of plants for each treatments.

Table 4.5 : The mean number of leaves of plants for each treatments in homogeneous subsets.

LEAVES				
	Treatment	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a]	T5	3	3.33	
	T0	3	3.67	3.67
	T4	3	4.33	4.33
	T1	3	5.00	5.00
	T2	3	5.00	5.00
	T7	3	5.00	5.00
	T3	3	5.67	5.67
	T6	3		6.67
	Sig.		.225	.062

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 4.6: The average number of leaves of plant for each treatments

Treatment	Number of leaves
T_0R_1	4
T_0R_2	4
T_0R_3	3
T_1R_1	6
T_1R_2	4
T_1R_3	5
T_2R_1	5
T_2R_2	5
T_2R_3	5
T_3R_1	8
T_3R_2	4
T_3R_3	5
T_4R_1	4
T_4R_2	4
T_4R_3	5
T_5R_1	4
T_5R_2	4
T_5R_3	2
T_6R_1	6
T_6R_2	6
T_6R_3	8
T_7R_1	5

T_7R_2	6
T_7R_3	4

4.1.4 Planting Media pH

Unlike height and weight, planting media pH does not show many differences in each treatment compared to the controlled plants. Since in this research I was using cocopeat instead of soil, I took the pH value of the cocopeat that was used as a control, T_0. The average pH value of T_0 was 6.4. While T_2 and T_7 had the same mean value of soil pH, which was 6.6, it was the greatest value recorded compared to controlled plants. The least mean value of pH was recorded for T_3, which was 6.1. Although it is the lowest value shown, it does not make much difference when compared to controlled plants and other treatments. Besides, T_1 and T_5 also recorded the same average pH value, which was 6.5. The average pH value for T_4 and T_6 was 6.4 and 6.3, respectively. According to ANOVA, planting media containing different ratios of biochar and BSFL frass have no significant effect on the pH value of the planting media (Table 4.24 appendices).

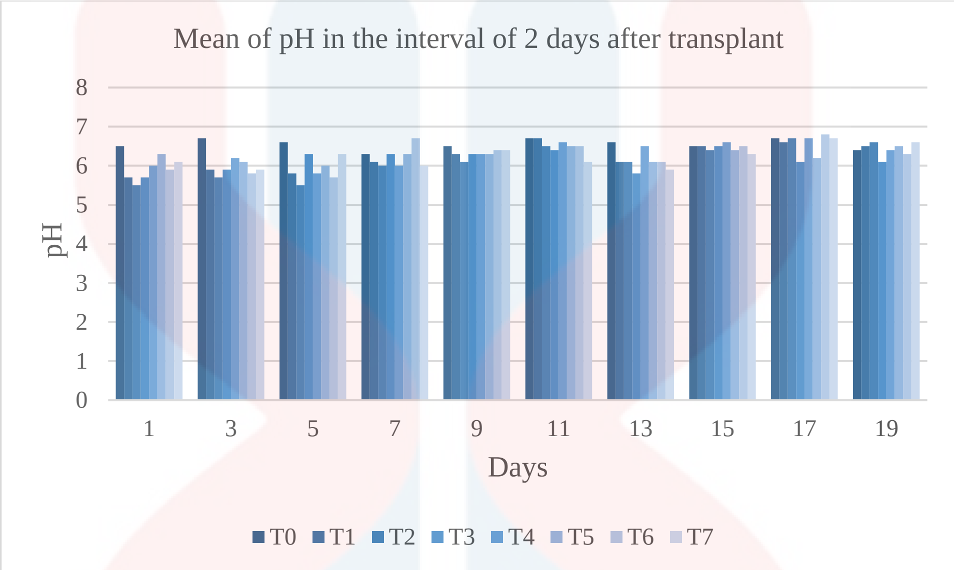

Figure 4.5 : The mean of pH of plants for each treatments.

Table 4.7 : The mean of pH of plants for each treatments in homogeneous subsets.

pH			
	Treatment	N	Subset for alpha = 0.05
			1
Tukey HSD[a]	T3	3	6.133
	T6	3	6.333
	T4	3	6.400
	T0	3	6.400
	T1	3	6.467
	T5	3	6.533
	T2	3	6.600
	T7	3	6.600
	Sig.		.703

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

4.1.5 NPK Content in Each Treatment

Nitrogen (N), Phosphorus (P) and Potassium (K) are very crucial for plants to grow healthy and well. In general, BSFL frass contained more nutrients than biochar, but biochar contains more carbon and chloride ions (Song et al., 2021). NPK content has also been taken from biochar and BSFL to find out how much nitrogen is in the fertiliser and it will be compared with treatment 1 and treatment 5. This is because at T_1 and T_5, only BSFL frass and biochar were applied, respectively. And it will be easy for us to compare the NPK content before and after planting. T_1 has the greatest nitrogen content, which was 5.5 mL, followed by T_4, which had 5.4 mL, and then T_2 and T_3, which has the same amount of nitrogen, which was 5.1 mL. The nitrogen content in T_6, which was 2.4 mL. The nitrogen content in T_7 and T_0 was 2.2 mL and 1.4 mL, respectively. While the nitrogen content of T_5 has the lowest value compared to other treatments, which was only 1.2 mL, but it does not show much difference when compared to control plants. Moreover, nitrogen content in biochar and BSFL frass was 2.2 mL and 19.9 mL, respectively.

Next, the phosphorus content in the control, treatments, biochar and BSFL frass were identified using spectrophotometer. T_1 has the greatest phosphorus content, which was 685, followed by T_7, which has 413.34, and then T_4 and T_5, which was 384.17 and 341.30, respectively. Besides, phosphorus content in T_5, which has 341.30. Meanwhile, the phosphorus content in T_2, T_6 and T_0 was, 286.67, 274.17 and 268.54, respectively. While the phosphorus content of T_3 has the lowest value compared to control plants and other treatments, which was only 80.56. Furthermore, phosphorus content in biochar and BSFL frass was 273.89 and 546.67, respectively.

Lastly, the potassium content in the control, treatments, biochar and BSFL frass were identified using Horiba LAQUAtwin Potassium ion meter apparatus. T_4 has the greatest potassium content, which was 560,000 ppm, followed by T_1, which has 350,000 ppm, and then T_7 and T_3, which was 296,667 ppm and 263,333 ppm, respectively. Besides, potassium content in T_6, which has 240,000 ppm. Meanwhile, the potassium content in T_2 and T_5 was, 193,333 ppm and 186,667 ppm, respectively. While the potassium content of control variable, T_0 has the lowest value compared to and other treatments, which was only 152,333 ppm. Furthermore, potassium content in biochar and BSFL frass was 530,000 ppm and 933,333 ppm, respectively.

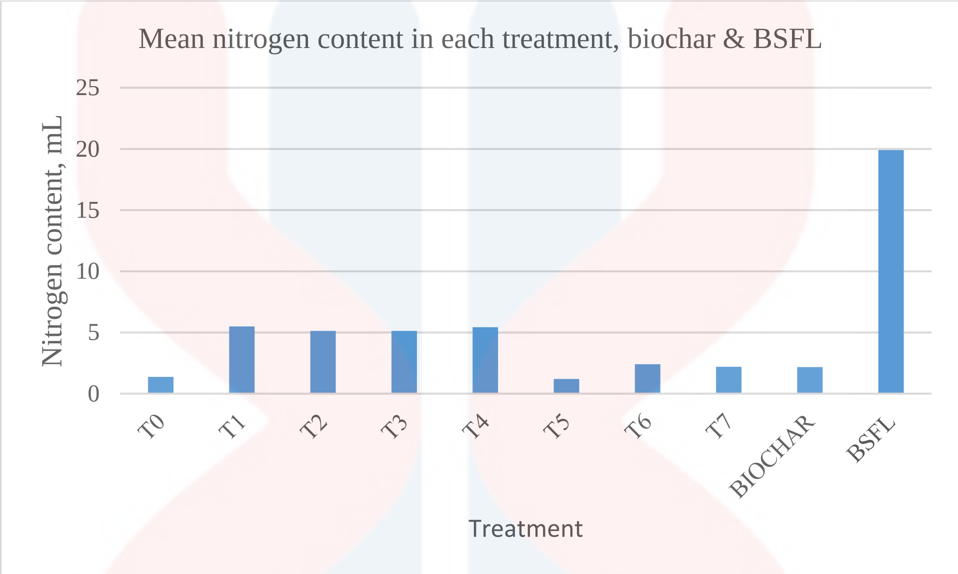

Figure 4.6 : The mean of nitrogen content of plants for each treatments, biochar and BSFL

Table 4.8 : The mean of nitrogen content of plants for each treatments, biochar and BSFL in homogeneous subsets.

NITROGEN						
	Treatment	N	Subset for alpha = 0.05			
			1	2	3	4
Tukey HSD[a]	T5	3	1.200			
	T0	3	1.367	1.367		
	Biochar	3	2.167	2.167	2.167	
	T7	3	2.200	2.200	2.200	
	T6	3	2.400	2.400	2.400	
	T2	3		5.133	5.133	
	T3	3		5.133	5.133	
	T4	3			5.433	
	T1	3			5.500	
	Frass	3				19.900
	Sig.		.976	.052	.114	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

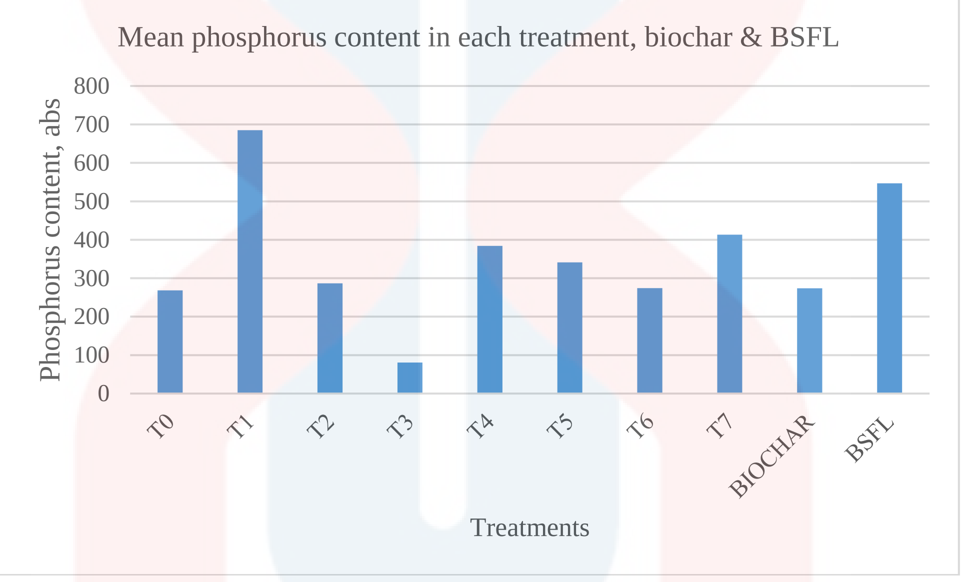

Figure 4.7 : The mean of phosphorus content of plants for each treatments, biochar and BSFL.

Table 4.9 : The mean of phosphorus content of plants for each treatments, biochar and BSFL in homogeneous subsets.

PHOSPHORUS			
	Treatment	N	Subset for alpha = 0.05
			1
Tukey HSD[a]	3	3	80.5567
	0	3	268.5367
	B	3	273.8900
	6	3	274.1667
	2	3	286.6667
	5	3	341.2967

	4	3	384.1667
	7	3	413.3367
	F	3	546.6667
	1	3	685.0000
	Sig.		.601
Means for groups in homogeneous subsets are displayed.			
a. Uses Harmonic Mean Sample Size = 3.000.			

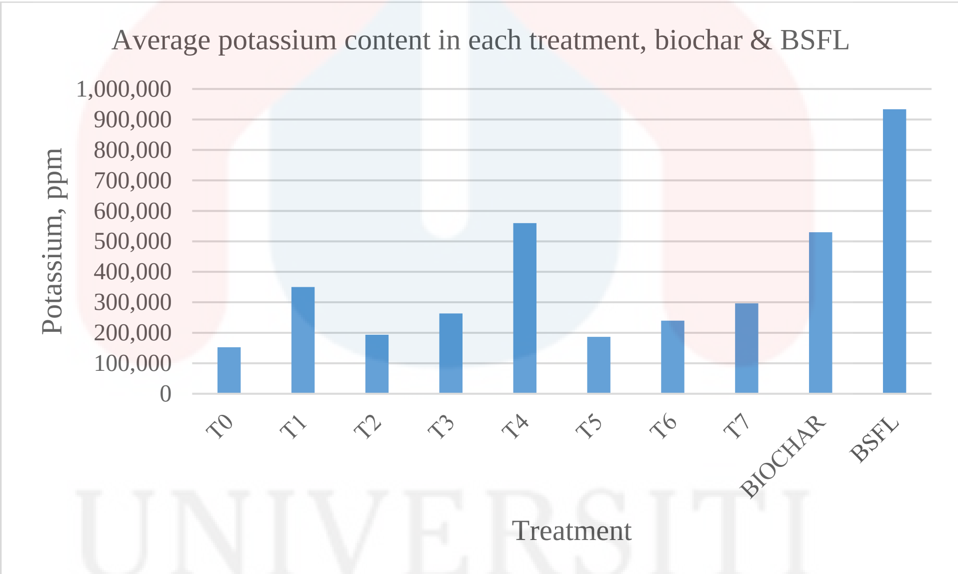

Figure 4.8 : The mean of potassium content of plants for each treatments, biochar and BSFL.

Table 4.10 : The mean of potassium content of plants for each treatments, biochar and BSFL in homogeneous subsets.

POTASSIUM, ppm					
	Treatment	N	Subset for alpha = 0.05		
			1	2	3
Tukey HSD[a]	T0	3	152333.33		

	T5	3	186666.67		
	T2	3	193333.33		
	T6	3	240000.00		
	T3	3	263333.33		
	T7	3	296666.67		
	T1	3	350000.00		
	Biochar	3	530000.00	530000.00	
	T4	3	560000.00	560000.00	
	Frass	3		933333.33	
	Sig.		.053	.057	
Means for groups in homogeneous subsets are displayed.					
a. Uses Harmonic Mean Sample Size = 3.000.					

4.2 Discussion

The seeds start to germinate on the 4th day after sowing, and true leaves start to grow on the 8th day. The plants showed much difference, neither in height nor in the number of leaves. In the first week after transplanting, T_1 was taller than control plants and other treatments. T_1 contains 10 g of BSFL frass, so initially, it grows taller and faster compared to other treatments. In the 2nd week, the plants that were treated with 6.6 g of biochar and 3.3 g of BSFL frass (T_6) grew taller than the other treatments. When it is compared on harvest week, T_6 grows taller, but it is thinner compared to T_1. Although T_1, was a bit shorter than T_6, it’s dry and fresh weight was quite high compared to other treatments. Even the number of leaves in T_1 grows faster and healthier. Based on the jimao choy plant’s growth, nitrogen plays a major role in weight. High nitrogen content in the soil will increase the weight of a plant or fruit. In general, nitrogen is used by plants as a building block to make enzymes and proteins. From this, we can conclude that since T_1 was treated with BSFL only, which has high nitrogen content, the fresh and dry weight of the plant is higher than other treatments because of the high density of cell components.

Other than that, the appearance, such as the colour of the leaves, of the plants has also been observed. The plants grow greener and healthier, but by the second week, most of the plants appear greenish-yellow. This situation is known as chlorosis. Chlorosis is a visible outcome of the plant's inability to produce enough chlorophyll for photosynthesis (Allentuck Landscaping, 2015). Plants get their green hue from chlorophyll, and if there is not enough, the leaves turn either pale or yellow. The reason why my plants appeared greenish yellow was because of the weather. It was raining all week and there was lack of sunlight. Chlorophyll is responsible for a plant's bright green hue. This material absorbs sunlight and transforms it into energy that is beneficial to plants (Witz, 2021). Chlorophyll cannot accomplish its work if the plants aren't getting enough sunlight. Yellowing in leaves and reduction in growth were noticed.

Furthermore, with the exception of T_0 (control variable) and T_5 (10 g of biochar), all of the plants appear greener and healthier on harvest day. From the results we obtained, nutrient content (NPK) in both treatments was very low. The height of the plants from these two treatments was shorter, and the leaves looked yellow and unhealthy. This is because the plants do not get enough nutrients to grow well. In this way, phosphorus is responsible for the strong growth of a plant. Insufficient phosphorus will lead to stunted growth and nutrient will not transport sufficiently to the plant (Anxin, n.d.). Besides, the yellowing in leaves was caused by low intake of water by the plant. In this case, potassium plays major role in helping the plant use water more efficiently, which helps to minimise infections and heat damage (Anxin, n.d.). Insufficiency of these two elements, causes the plants in T_0 and T_5 to turn yellow and the growth was inhibit or slows down.

Furthermore, the BSFL treatments resulted in a great difference when compared to the control plants and the other treatments. This due to frass contain high nitrogen, phosphorus and potassium, compared to biochar and controlled treatment. A research was carried out by Zahn (2017), to study “The effects of insect frass created by Hermetia illucens on spring onion growth and soil fertility”. In this study, the author applies BSFL frass, compost and NPK fertilizer separately to identify the effects of these three fertilizers on spring onion growth and soil fertility. This study found that nitrogen and phosphorus were found abundantly in the frass (Zahn, 2017). At the same time, the optimum application of BSFL frass to the plant results in increasing the yield of the spring onion. Another study were carried out by Bortolini et al. (2020), shows that application of chicken manure treated with BSFL frass increase the soil properties and increases nutrient availability for the plants.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The objectives of this study were met by determining the impact of different ratios of planting media enhanced with biochar and BSFL frass on the growth and yield of the jimao choy plant. From the results we obtained, we can conclude that T_1 (0 : 1) and T_6 (2 : 1)show the best results compared to other treatments in many things. T_1 plants show a better result in weight, while T_6 plants show a better result in height and number of leaves. The fresh and dry weights of the T_1 plant were higher. Meanwhile, T_6 was taller and had a higher number of leaves and branches. However, there was no significant difference between T_1 and T_6. In these 2 treatments, BSFL frass plays a major role in plants' growth and yield. This is probably due to the fact that frass has higher nutrient contents than biochar. Furthermore, the nitrogen, phosphorus, and potassium content in biochar and BSFL frass were analysed. From the results obtained, BSFL frass contains more NPK content than biochar. Because the frass contained more nutrients, it had a positive effect on the growth parameters and yield of the jimao choy plant.

5.2 Recommendation

This research study suggests that to get better results, utilising biochar and BSFL frass should be conducted in a wide range or using it on fruit plants to determine the ideal concentration and quantity that can be used to grow viable plants in an organic manner. This is because, in this research, it was only used a short mature leafy vegetable. Perhaps, this research should carry out with other fruit vegetables to get better results. Besides, it is also suggested to analyse other nutrient content in the soil sample, such as magnesium, calcium, etc., and find nutrient intake by each plant from the media supplied. Furthermore, the percentage of NPK utilised by the plant also needed to study further, to know the optimum requirement of NPK for the specific plant type. Insect frass has shown promise in terms of crop production and growth performance. Furthermore, a study into the chemical makeup of insect frass will aid in the creation of bio-organic for ecologically benign, long-term agricultural systems. The bio-organic composition should be used more frequently in the future so that farmers can get it.

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APPENDICES

Figure 4.9: Block of pressed cocopeat was immersed in water

Figure 4.10: Process of drying coco peat

Figure 4.11: Seeds germinated after 4 days

Figure 4.12: Weighing biochar and frass

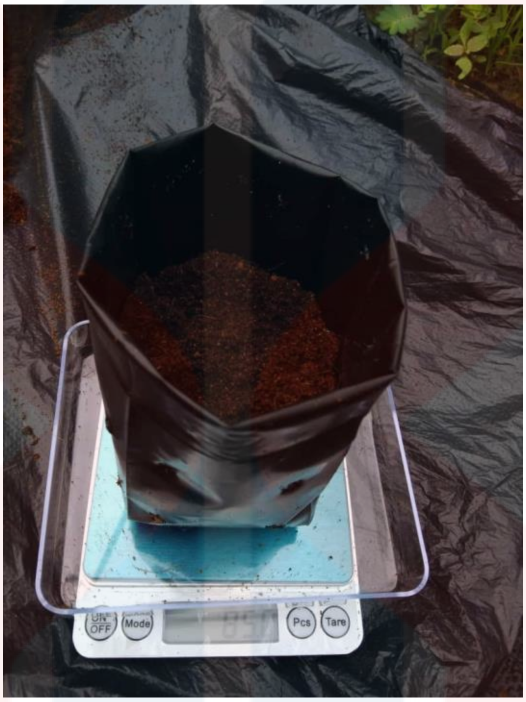

Figure 4.13: Weighing coco peat

Figure 4.14: Plants after transfer into polybag

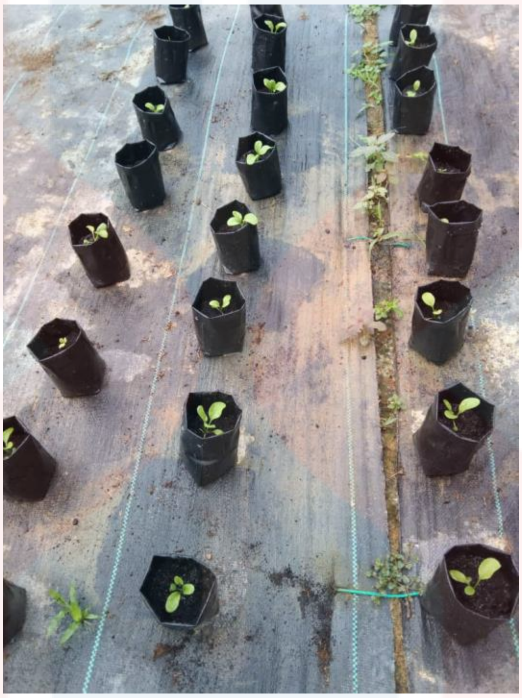

Figure 4.15: Plants on week 1

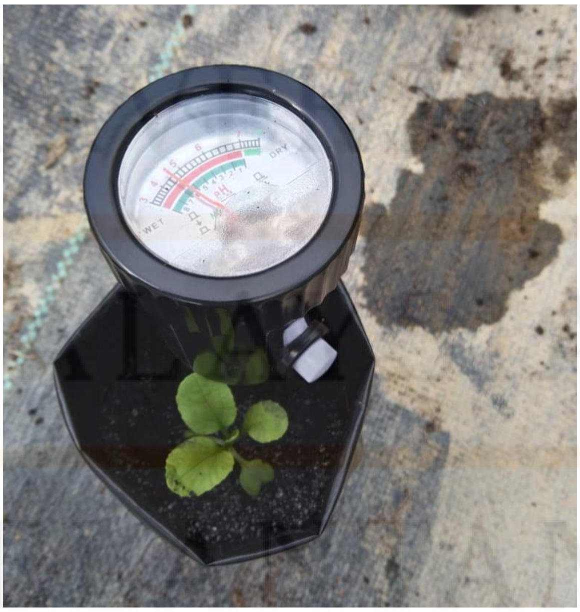

Figure 4.16: Checking pH of the soil

Figure 4.17: Plants on week 2

Figure 4.18: Plants on week 3 (harvest stage)

Figure 4.19: Setting up plants before checking dry weight using oven

Figure 4.20: Plant after dried

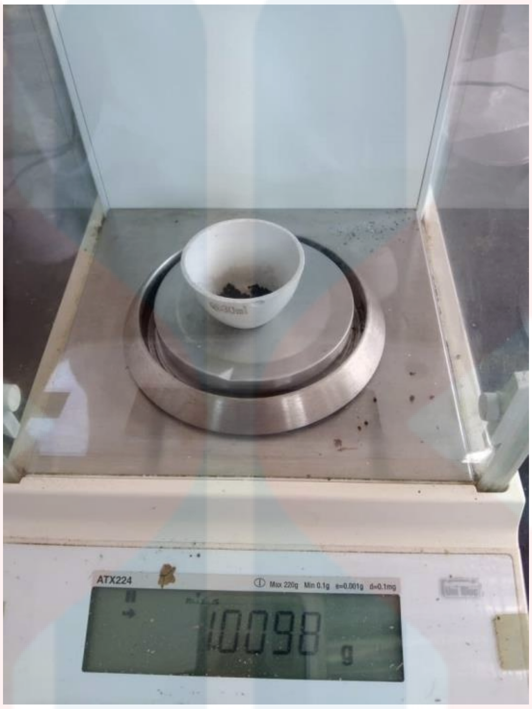

Figure 4.21: Weighing sample for ashing

Figure 4.22: Samples in furnace (ashing)

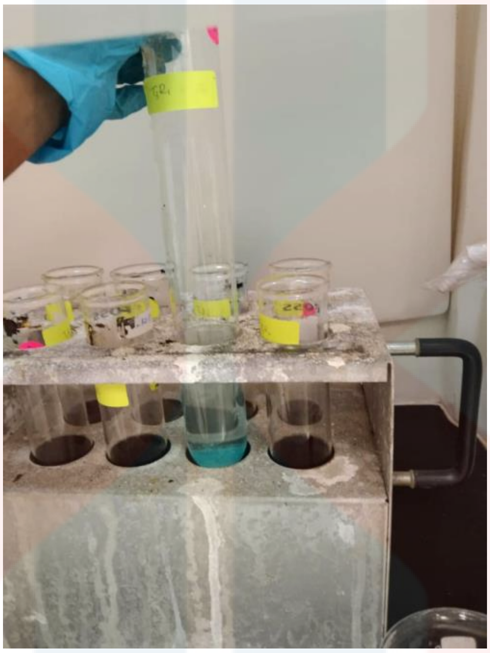

Figure 4.23: Kjeldahl method (digestion)

Figure 4.24: Kjeldahl method (distillation)

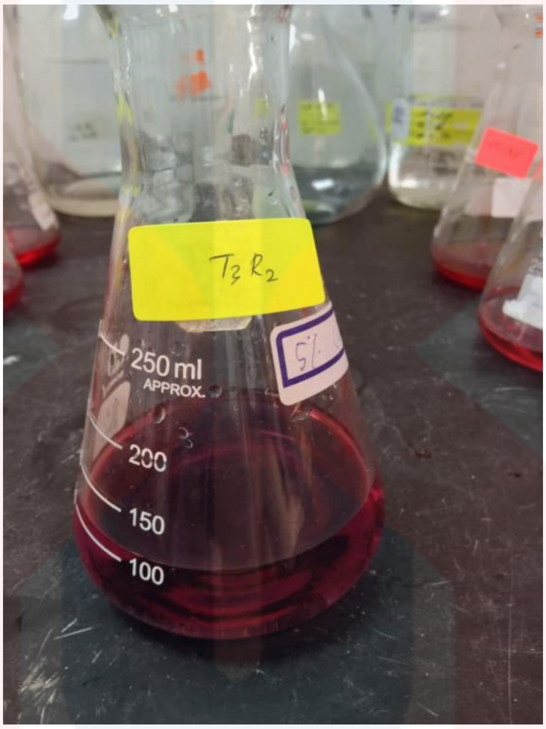

Figure 4.25: Preparation of base for titration (Kjeldahl method)

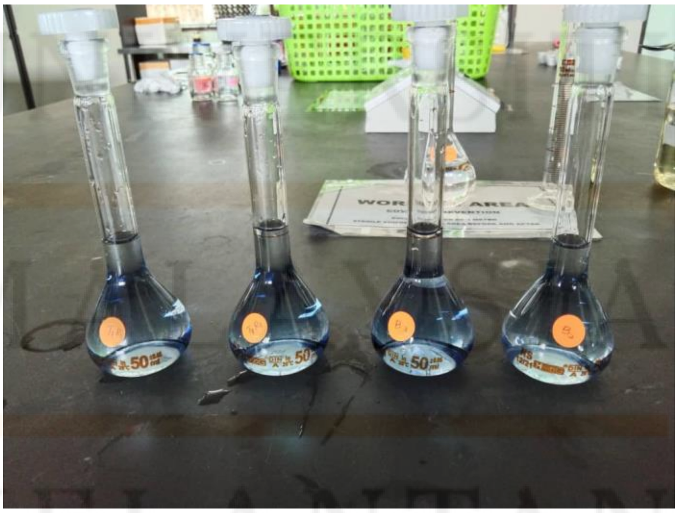

Figure 4.26: Colour development method

Figure 4.27: Process of identifying potassium content using Horiba LAQUAtwin

Table 4.11: Tukey HSD test of descriptives

Descriptives								
Height in cm								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
T0	3	6.800	2.2068	1.2741	1.318	12.282	4.5	8.9
T1	3	13.067	2.7025	1.5603	6.353	19.780	10.3	15.7
T2	3	14.433	1.4364	.8293	10.865	18.002	12.8	15.5
T3	3	10.667	3.8188	2.2048	1.180	20.153	6.5	14.0
T4	3	12.467	1.4503	.8373	8.864	16.069	11.0	13.9
T5	3	5.967	1.8502	1.0682	1.370	10.563	4.1	7.8
T6	3	15.067	1.5044	.8686	11.329	18.804	13.5	16.5
T7	3	14.267	1.5373	.8876	10.448	18.086	12.5	15.3
Total	24	11.592	3.8168	.7791	9.980	13.203	4.1	16.5

Fresh Weight in g

T0	3	.3033	.27025	.15603	-.3680	.9747	.10	.61
T1	3	17.2367	4.90806	2.83367	5.0444	29.4290	13.20	22.70
T2	3	13.0000	3.75899	2.17025	3.6622	22.3378	9.40	16.90
T3	3	10.2000	9.10000	5.25389	-12.4057	32.8057	1.70	19.80
T4	3	10.5667	3.29292	1.90117	2.3866	18.7467	6.80	12.90
T5	3	.2833	.18771	.10837	-.1830	.7496	.08	.45
T6	3	10.9333	.95044	.54874	8.5723	13.2944	10.00	11.90
T7	3	11.4333	1.96299	1.13333	6.5570	16.3097	10.30	13.70
Total	24	9.2446	6.65636	1.35872	6.4338	12.0553	.08	22.70

Dry Weight in g

T0	3	.034267	.0253338	.0146265	-.028666	.097199	.0114	.0615
T1	3	1.142833	.2700178	.1558949	.472072	1.813595	.9552	1.4523
T2	3	1.007100	.1954945	.1128688	.521465	1.492735	.8543	1.2274
T3	3	.708933	.6350778	.3666624	-.868687	2.286554	.1185	1.3808
T4	3	.753600	.2685617	.1550542	.086456	1.420744	.4471	.9477
T5	3	.036533	.0208447	.0120347	-.015248	.088315	.0135	.0541
T6	3	1.252100	.6382849	.3685140	-.333488	2.837688	.8420	1.9875
T7	3	.976733	.1201121	.0693468	.678358	1.275108	.8421	1.0729
Total	24	.739013	.5379872	.1098162	.511840	.966185	.0114	1.9875

LEAVES

T0	3	3.67	.577	.333	2.23	5.10	3	4
T1	3	5.00	1.000	.577	2.52	7.48	4	6
T2	3	5.00	.000	.000	5.00	5.00	5	5
T3	3	5.67	2.082	1.202	.50	10.84	4	8
T4	3	4.33	.577	.333	2.90	5.77	4	5
T5	3	3.33	1.155	.667	.46	6.20	2	4
T6	3	6.67	1.155	.667	3.80	9.54	6	8
T7	3	5.00	1.000	.577	2.52	7.48	4	6
Total	24	4.83	1.373	.280	4.25	5.41	2	8

pH

T0	3	6.400	.0000	.0000	6.400	6.400	6.4	6.4
T1	3	6.467	.4163	.2404	5.432	7.501	6.0	6.8
T2	3	6.600	.0000	.0000	6.600	6.600	6.6	6.6

T3	3	6.133	.5774	.3333	4.699	7.568	5.8	6.8
T4	3	6.400	.4000	.2309	5.406	7.394	6.0	6.8
T5	3	6.533	.2309	.1333	5.960	7.107	6.4	6.8
T6	3	6.333	.4619	.2667	5.186	7.481	5.8	6.6
T7	3	6.600	.0000	.0000	6.600	6.600	6.6	6.6
Total	24	6.433	.3212	.0656	6.298	6.569	5.8	6.8

Nitrogen content, mL

T0	3	1.367	.7371	.4256	-.464	3.198	.8	2.2
T1	3	5.500	2.3065	1.3317	-.230	11.230	3.1	7.7
T2	3	5.133	1.6289	.9404	1.087	9.180	4.0	7.0
T3	3	5.133	.7095	.4096	3.371	6.896	4.5	5.9
T4	3	5.433	2.1455	1.2387	.104	10.763	4.0	7.9
T5	3	1.200	.4359	.2517	.117	2.283	.9	1.7
T6	3	2.400	.4583	.2646	1.262	3.538	1.9	2.8
T7	3	2.200	.3606	.2082	1.304	3.096	1.9	2.6
Biochar	3	2.167	.4163	.2404	1.132	3.201	1.7	2.5
Frass	3	19.900	1.6703	.9644	15.751	24.049	18.4	21.7
Total	30	5.043	5.4216	.9899	3.019	7.068	.8	21.7

Phosphorus

T0	3	268.5367	399.65884	230.74314	-724.2709	1261.3443	33.82	730.00
T1	3	685.0000	685.87535	395.99032	-1018.8088	2388.8088	20.00	1390.00
T2	3	286.6667	129.06717	74.51696	-33.9539	607.2873	200.00	435.00
T3	3	80.5567	10.84572	6.26178	53.6144	107.4989	70.00	91.67
T4	3	384.1667	223.21981	128.87602	-170.3421	938.6754	180.00	622.50
T5	3	341.2967	479.61416	276.90537	-850.1310	1532.7243	55.00	895.00
T6	3	274.1667	212.28420	122.56234	-253.1765	801.5099	75.00	497.50
T7	3	413.3367	146.82756	84.77093	48.5968	778.0766	311.67	581.67
Biochar	3	273.8900	109.56321	63.25635	1.7199	546.0601	175.00	391.67
Frass	3	546.6667	590.06985	340.67698	-919.1481	2012.4814	111.67	1218.33
Total	30	355.4283	345.37080	63.05579	226.4648	484.3919	20.00	1390.00

Potassium in ppm								
T0	3	152333.33	69255.565	39984.719	-19707.03	324373.69	97000	230000
T1	3	350000.00	108166.538	62449.980	81299.42	618700.58	260000	470000
T2	3	193333.33	15275.252	8819.171	155387.50	231279.16	180000	210000
T3	3	263333.33	102632.029	59254.629	8381.24	518285.43	150000	350000
T4	3	560000.00	204205.779	117898.261	52724.72	1067275.28	400000	790000
T5	3	186666.67	90737.717	52387.445	-38738.32	412071.65	120000	290000
T6	3	240000.00	112694.277	65064.071	-39948.10	519948.10	170000	370000
T7	3	296666.67	263881.286	152351.932	-358850.79	952184.12	120000	600000
Biochar	3	530000.00	204205.779	117898.261	22724.72	1037275.28	370000	760000
Frass	3	933333.33	32145.503	18559.215	853479.48	1013187.19	910000	970000
Total	30	370566.67	261324.172	47711.048	272986.62	468146.72	97000	970000

Table 4.12: Tukey HSD test of multiple comparisons for height

Dependent Variable: Height in cm

	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Tukey HSD	T0	T1	-6.2667*	1.8022	.049	-12.506	-.027
		T2	-7.6333*	1.8022	.011	-13.873	-1.394
		T3	-3.8667	1.8022	.429	-10.106	2.373
		T4	-5.6667	1.8022	.090	-11.906	.573
		T5	.8333	1.8022	1.000	-5.406	7.073
		T6	-8.2667*	1.8022	.006	-14.506	-2.027
		T7	-7.4667*	1.8022	.014	-13.706	-1.227

T1	T0	6.2667*	1.8022	.049	.027	12.506
	T2	-1.3667	1.8022	.993	-7.606	4.873
	T3	2.4000	1.8022	.874	-3.839	8.639
	T4	.6000	1.8022	1.000	-5.639	6.839
	T5	7.1000*	1.8022	.020	.861	13.339
	T6	-2.0000	1.8022	.945	-8.239	4.239
	T7	-1.2000	1.8022	.997	-7.439	5.039
T2	T0	7.6333*	1.8022	.011	1.394	13.873
	T1	1.3667	1.8022	.993	-4.873	7.606
	T3	3.7667	1.8022	.460	-2.473	10.006
	T4	1.9667	1.8022	.950	-4.273	8.206
	T5	8.4667*	1.8022	.005	2.227	14.706
	T6	-.6333	1.8022	1.000	-6.873	5.606
	T7	.1667	1.8022	1.000	-6.073	6.406
T3	T0	3.8667	1.8022	.429	-2.373	10.106
	T1	-2.4000	1.8022	.874	-8.639	3.839
	T2	-3.7667	1.8022	.460	-10.006	2.473
	T4	-1.8000	1.8022	.968	-8.039	4.439
	T5	4.7000	1.8022	.222	-1.539	10.939
	T6	-4.4000	1.8022	.286	-10.639	1.839
	T7	-3.6000	1.8022	.512	-9.839	2.639
T4	T0	5.6667	1.8022	.090	-.573	11.906
	T1	-.6000	1.8022	1.000	-6.839	5.639
	T2	-1.9667	1.8022	.950	-8.206	4.273
	T3	1.8000	1.8022	.968	-4.439	8.039
	T5	6.5000*	1.8022	.038	.261	12.739
	T6	-2.6000	1.8022	.825	-8.839	3.639
	T7	-1.8000	1.8022	.968	-8.039	4.439
T5	T0	-.8333	1.8022	1.000	-7.073	5.406
	T1	-7.1000*	1.8022	.020	-13.339	-.861
	T2	-8.4667*	1.8022	.005	-14.706	-2.227
	T3	-4.7000	1.8022	.222	-10.939	1.539
	T4	-6.5000*	1.8022	.038	-12.739	-.261
	T6	-9.1000*	1.8022	.002	-15.339	-2.861
	T7	-8.3000*	1.8022	.005	-14.539	-2.061
T6	T0	8.2667*	1.8022	.006	2.027	14.506

		T1	2.0000	1.8022	.945	-4.239	8.239
		T2	.6333	1.8022	1.000	-5.606	6.873
		T3	4.4000	1.8022	.286	-1.839	10.639
		T4	2.6000	1.8022	.825	-3.639	8.839
		T5	9.1000*	1.8022	.002	2.861	15.339
		T7	.8000	1.8022	1.000	-5.439	7.039
	T7	T0	7.4667*	1.8022	.014	1.227	13.706
		T1	1.2000	1.8022	.997	-5.039	7.439
		T2	-.1667	1.8022	1.000	-6.406	6.073
		T3	3.6000	1.8022	.512	-2.639	9.839
		T4	1.8000	1.8022	.968	-4.439	8.039
		T5	8.3000*	1.8022	.005	2.061	14.539
		T6	-.8000	1.8022	1.000	-7.039	5.439
LSD	T0	T1	-6.2667*	1.8022	.003	-10.087	-2.446
		T2	-7.6333*	1.8022	.001	-11.454	-3.813
		T3	-3.8667*	1.8022	.048	-7.687	-.046
		T4	-5.6667*	1.8022	.006	-9.487	-1.846
		T5	.8333	1.8022	.650	-2.987	4.654
		T6	-8.2667*	1.8022	.000	-12.087	-4.446
		T7	-7.4667*	1.8022	.001	-11.287	-3.646
	T1	T0	6.2667*	1.8022	.003	2.446	10.087
		T2	-1.3667	1.8022	.459	-5.187	2.454
		T3	2.4000	1.8022	.202	-1.420	6.220
		T4	.6000	1.8022	.744	-3.220	4.420
		T5	7.1000*	1.8022	.001	3.280	10.920
		T6	-2.0000	1.8022	.283	-5.820	1.820
		T7	-1.2000	1.8022	.515	-5.020	2.620
	T2	T0	7.6333*	1.8022	.001	3.813	11.454
		T1	1.3667	1.8022	.459	-2.454	5.187
		T3	3.7667	1.8022	.053	-.054	7.587
		T4	1.9667	1.8022	.291	-1.854	5.787
		T5	8.4667*	1.8022	.000	4.646	12.287
		T6	-.6333	1.8022	.730	-4.454	3.187
		T7	.1667	1.8022	.927	-3.654	3.987
	T3	T0	3.8667*	1.8022	.048	.046	7.687
		T1	-2.4000	1.8022	.202	-6.220	1.420

		T2	-3.7667	1.8022	.053	-7.587	.054
		T4	-1.8000	1.8022	.333	-5.620	2.020
		T5	4.7000*	1.8022	.019	.880	8.520
		T6	-4.4000*	1.8022	.027	-8.220	-.580
		T7	-3.6000	1.8022	.063	-7.420	.220
	T4	T0	5.6667*	1.8022	.006	1.846	9.487
		T1	-.6000	1.8022	.744	-4.420	3.220
		T2	-1.9667	1.8022	.291	-5.787	1.854
		T3	1.8000	1.8022	.333	-2.020	5.620
		T5	6.5000*	1.8022	.002	2.680	10.320
		T6	-2.6000	1.8022	.168	-6.420	1.220
		T7	-1.8000	1.8022	.333	-5.620	2.020
	T5	T0	-.8333	1.8022	.650	-4.654	2.987
		T1	-7.1000*	1.8022	.001	-10.920	-3.280
		T2	-8.4667*	1.8022	.000	-12.287	-4.646
		T3	-4.7000*	1.8022	.019	-8.520	-.880
		T4	-6.5000*	1.8022	.002	-10.320	-2.680
		T6	-9.1000*	1.8022	.000	-12.920	-5.280
		T7	-8.3000*	1.8022	.000	-12.120	-4.480
	T6	T0	8.2667*	1.8022	.000	4.446	12.087
		T1	2.0000	1.8022	.283	-1.820	5.820
		T2	.6333	1.8022	.730	-3.187	4.454
		T3	4.4000*	1.8022	.027	.580	8.220
		T4	2.6000	1.8022	.168	-1.220	6.420
		T5	9.1000*	1.8022	.000	5.280	12.920
		T7	.8000	1.8022	.663	-3.020	4.620
	T7	T0	7.4667*	1.8022	.001	3.646	11.287
		T1	1.2000	1.8022	.515	-2.620	5.020
		T2	-.1667	1.8022	.927	-3.987	3.654
		T3	3.6000	1.8022	.063	-.220	7.420
		T4	1.8000	1.8022	.333	-2.020	5.620
		T5	8.3000*	1.8022	.000	4.480	12.120
		T6	-.8000	1.8022	.663	-4.620	3.020

*. The mean difference is significant at the 0.05 level.

Table 4.13: Tukey HSD test of multiple comparisons for fresh weight

Dependent Variable: Fresh Weight in g

	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	T0	T1	-16.93333*	3.37561	.002	-28.6202	-5.2464
		T2	-12.69667*	3.37561	.028	-24.3836	-1.0098
		T3	-9.89667	3.37561	.130	-21.5836	1.7902
		T4	-10.26333	3.37561	.108	-21.9502	1.4236
		T5	.02000	3.37561	1.000	-11.6669	11.7069
		T6	-10.63000	3.37561	.089	-22.3169	1.0569
		T6	-11.13000	3.37561	.068	-22.8169	.5569
	T1	T0	16.93333*	3.37561	.002	5.2464	28.6202
		T2	4.23667	3.37561	.902	-7.4502	15.9236
		T3	7.03667	3.37561	.463	-4.6502	18.7236
		T4	6.67000	3.37561	.525	-5.0169	18.3569
		T5	16.95333*	3.37561	.002	5.2664	28.6402
		T6	6.30333	3.37561	.589	-5.3836	17.9902
		T6	5.80333	3.37561	.676	-5.8836	17.4902
	T2	T0	12.69667*	3.37561	.028	1.0098	24.3836
		T1	-4.23667	3.37561	.902	-15.9236	7.4502
		T3	2.80000	3.37561	.988	-8.8869	14.4869
		T4	2.43333	3.37561	.995	-9.2536	14.1202
		T5	12.71667*	3.37561	.028	1.0298	24.4036
		T6	2.06667	3.37561	.998	-9.6202	13.7536
		T6	1.56667	3.37561	1.000	-10.1202	13.2536
	T3	T0	9.89667	3.37561	.130	-1.7902	21.5836
		T1	-7.03667	3.37561	.463	-18.7236	4.6502
		T2	-2.80000	3.37561	.988	-14.4869	8.8869
		T4	-.36667	3.37561	1.000	-12.0536	11.3202
		T5	9.91667	3.37561	.129	-1.7702	21.6036
		T6	-.73333	3.37561	1.000	-12.4202	10.9536
		T6	-1.23333	3.37561	1.000	-12.9202	10.4536
	T4	T0	10.26333	3.37561	.108	-1.4236	21.9502
		T1	-6.67000	3.37561	.525	-18.3569	5.0169
		T2	-2.43333	3.37561	.995	-14.1202	9.2536

		T3	.36667	3.37561	1.000	-11.3202	12.0536
		T5	10.28333	3.37561	.107	-1.4036	21.9702
		T6	-.36667	3.37561	1.000	-12.0536	11.3202
		T6	-.86667	3.37561	1.000	-12.5536	10.8202
	T5	T0	-.02000	3.37561	1.000	-11.7069	11.6669
		T1	-16.95333*	3.37561	.002	-28.6402	-5.2664
		T2	-12.71667*	3.37561	.028	-24.4036	-1.0298
		T3	-9.91667	3.37561	.129	-21.6036	1.7702
		T4	-10.28333	3.37561	.107	-21.9702	1.4036
		T6	-10.65000	3.37561	.088	-22.3369	1.0369
		T6	-11.15000	3.37561	.067	-22.8369	.5369
	T6	T0	10.63000	3.37561	.089	-1.0569	22.3169
		T1	-6.30333	3.37561	.589	-17.9902	5.3836
		T2	-2.06667	3.37561	.998	-13.7536	9.6202
		T3	.73333	3.37561	1.000	-10.9536	12.4202
		T4	.36667	3.37561	1.000	-11.3202	12.0536
		T5	10.65000	3.37561	.088	-1.0369	22.3369
		T6	-.50000	3.37561	1.000	-12.1869	11.1869
	T7	T0	11.13000	3.37561	.068	-.5569	22.8169
		T1	-5.80333	3.37561	.676	-17.4902	5.8836
		T2	-1.56667	3.37561	1.000	-13.2536	10.1202
		T3	1.23333	3.37561	1.000	-10.4536	12.9202
		T4	.86667	3.37561	1.000	-10.8202	12.5536
		T5	11.15000	3.37561	.067	-.5369	22.8369
		T6	.50000	3.37561	1.000	-11.1869	12.1869
LSD	T0	T1	-16.93333*	3.37561	.000	-24.0893	-9.7773
		T2	-12.69667*	3.37561	.002	-19.8527	-5.5407
		T3	-9.89667*	3.37561	.010	-17.0527	-2.7407
		T4	-10.26333*	3.37561	.008	-17.4193	-3.1073
		T5	.02000	3.37561	.995	-7.1360	7.1760
		T6	-10.63000*	3.37561	.006	-17.7860	-3.4740
		T6	-11.13000*	3.37561	.005	-18.2860	-3.9740
	T1	T0	16.93333*	3.37561	.000	9.7773	24.0893
		T2	4.23667	3.37561	.227	-2.9193	11.3927
		T3	7.03667	3.37561	.053	-.1193	14.1927
		T4	6.67000	3.37561	.066	-.4860	13.8260

		T5	16.95333*	3.37561	.000	9.7973	24.1093
		T6	6.30333	3.37561	.080	-.8527	13.4593
		T6	5.80333	3.37561	.105	-1.3527	12.9593
	T2	T0	12.69667*	3.37561	.002	5.5407	19.8527
		T1	-4.23667	3.37561	.227	-11.3927	2.9193
		T3	2.80000	3.37561	.419	-4.3560	9.9560
		T4	2.43333	3.37561	.481	-4.7227	9.5893
		T5	12.71667*	3.37561	.002	5.5607	19.8727
		T6	2.06667	3.37561	.549	-5.0893	9.2227
		T6	1.56667	3.37561	.649	-5.5893	8.7227
	T3	T0	9.89667*	3.37561	.010	2.7407	17.0527
		T1	-7.03667	3.37561	.053	-14.1927	.1193
		T2	-2.80000	3.37561	.419	-9.9560	4.3560
		T4	-.36667	3.37561	.915	-7.5227	6.7893
		T5	9.91667*	3.37561	.010	2.7607	17.0727
		T6	-.73333	3.37561	.831	-7.8893	6.4227
		T6	-1.23333	3.37561	.720	-8.3893	5.9227
	T4	T0	10.26333*	3.37561	.008	3.1073	17.4193
		T1	-6.67000	3.37561	.066	-13.8260	.4860
		T2	-2.43333	3.37561	.481	-9.5893	4.7227
		T3	.36667	3.37561	.915	-6.7893	7.5227
		T5	10.28333*	3.37561	.008	3.1273	17.4393
		T6	-.36667	3.37561	.915	-7.5227	6.7893
		T6	-.86667	3.37561	.801	-8.0227	6.2893
	T5	T0	-.02000	3.37561	.995	-7.1760	7.1360
		T1	-16.95333*	3.37561	.000	-24.1093	-9.7973
		T2	-12.71667*	3.37561	.002	-19.8727	-5.5607
		T3	-9.91667*	3.37561	.010	-17.0727	-2.7607
		T4	-10.28333*	3.37561	.008	-17.4393	-3.1273
		T6	-10.65000*	3.37561	.006	-17.8060	-3.4940
		T6	-11.15000*	3.37561	.004	-18.3060	-3.9940
	T6	T0	10.63000*	3.37561	.006	3.4740	17.7860
		T1	-6.30333	3.37561	.080	-13.4593	.8527
		T2	-2.06667	3.37561	.549	-9.2227	5.0893
		T3	.73333	3.37561	.831	-6.4227	7.8893
		T4	.36667	3.37561	.915	-6.7893	7.5227

		T5	10.65000*	3.37561	.006	3.4940	17.8060
		T6	-.50000	3.37561	.884	-7.6560	6.6560
	T7	T0	11.13000*	3.37561	.005	3.9740	18.2860
		T1	-5.80333	3.37561	.105	-12.9593	1.3527
		T2	-1.56667	3.37561	.649	-8.7227	5.5893
		T3	1.23333	3.37561	.720	-5.9227	8.3893
		T4	.86667	3.37561	.801	-6.2893	8.0227
		T5	11.15000*	3.37561	.004	3.9940	18.3060
		T6	.50000	3.37561	.884	-6.6560	7.6560

*. The mean difference is significant at the 0.05 level.

Table 4.14: Tukey HSD test of multiple comparisons for dry weight

Dependent Variable: Dry Weight in g

	(I) Treatement	(J) Treatement	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Tukey HSD	T0	T1	-1.1085667*	.2900414	.025	-2.112734	-.104400
		T2	-.9728333	.2900414	.061	-1.977000	.031334
		T3	-.6746667	.2900414	.338	-1.678834	.329500
		T4	-.7193333	.2900414	.270	-1.723500	.284834
		T5	-.0022667	.2900414	1.000	-1.006434	1.001900
		T6	-1.2178333*	.2900414	.012	-2.222000	-.213666
		T6	-.9424667	.2900414	.074	-1.946634	.061700
	T1	T0	1.1085667*	.2900414	.025	.104400	2.112734
		T2	.1357333	.2900414	1.000	-.868434	1.139900
		T3	.4339000	.2900414	.799	-.570267	1.438067
		T4	.3892333	.2900414	.870	-.614934	1.393400
		T5	1.1063000*	.2900414	.026	.102133	2.110467
		T6	-.1092667	.2900414	1.000	-1.113434	.894900
		T6	.1661000	.2900414	.999	-.838067	1.170267
	T2	T0	.9728333	.2900414	.061	-.031334	1.977000
		T1	-.1357333	.2900414	1.000	-1.139900	.868434
		T3	.2981667	.2900414	.963	-.706000	1.302334
		T4	.2535000	.2900414	.985	-.750667	1.257667

	T5	.9705667	.2900414	.062	-.033600	1.974734
	T6	-.2450000	.2900414	.987	-1.249167	.759167
	T6	.0303667	.2900414	1.000	-.973800	1.034534
T3	T0	.6746667	.2900414	.338	-.329500	1.678834
	T1	-.4339000	.2900414	.799	-1.438067	.570267
	T2	-.2981667	.2900414	.963	-1.302334	.706000
	T4	-.0446667	.2900414	1.000	-1.048834	.959500
	T5	.6724000	.2900414	.341	-.331767	1.676567
	T6	-.5431667	.2900414	.586	-1.547334	.461000
	T6	-.2678000	.2900414	.979	-1.271967	.736367
T4	T0	.7193333	.2900414	.270	-.284834	1.723500
	T1	-.3892333	.2900414	.870	-1.393400	.614934
	T2	-.2535000	.2900414	.985	-1.257667	.750667
	T3	.0446667	.2900414	1.000	-.959500	1.048834
	T5	.7170667	.2900414	.273	-.287100	1.721234
	T6	-.4985000	.2900414	.677	-1.502667	.505667
	T6	-.2231333	.2900414	.993	-1.227300	.781034
T5	T0	.0022667	.2900414	1.000	-1.001900	1.006434
	T1	-1.1063000*	.2900414	.026	-2.110467	-.102133
	T2	-.9705667	.2900414	.062	-1.974734	.033600
	T3	-.6724000	.2900414	.341	-1.676567	.331767
	T4	-.7170667	.2900414	.273	-1.721234	.287100
	T6	-1.2155667*	.2900414	.012	-2.219734	-.211400
	T6	-.9402000	.2900414	.075	-1.944367	.063967
T6	T0	1.2178333*	.2900414	.012	.213666	2.222000
	T1	.1092667	.2900414	1.000	-.894900	1.113434
	T2	.2450000	.2900414	.987	-.759167	1.249167
	T3	.5431667	.2900414	.586	-.461000	1.547334
	T4	.4985000	.2900414	.677	-.505667	1.502667
	T5	1.2155667*	.2900414	.012	.211400	2.219734
	T6	.2753667	.2900414	.976	-.728800	1.279534
T7	T0	.9424667	.2900414	.074	-.061700	1.946634
	T1	-.1661000	.2900414	.999	-1.170267	.838067
	T2	-.0303667	.2900414	1.000	-1.034534	.973800
	T3	.2678000	.2900414	.979	-.736367	1.271967
	T4	.2231333	.2900414	.993	-.781034	1.227300

		T5	.9402000	.2900414	.075	-.063967	1.944367
		T6	-.2753667	.2900414	.976	-1.279534	.728800
LSD	T0	T1	-1.1085667*	.2900414	.002	-1.723427	-.493706
		T2	-.9728333*	.2900414	.004	-1.587694	-.357973
		T3	-.6746667*	.2900414	.033	-1.289527	-.059806
		T4	-.7193333*	.2900414	.025	-1.334194	-.104473
		T5	-.0022667	.2900414	.994	-.617127	.612594
		T6	-1.2178333*	.2900414	.001	-1.832694	-.602973
		T6	-.9424667*	.2900414	.005	-1.557327	-.327606
	T1	T0	1.1085667*	.2900414	.002	.493706	1.723427
		T2	.1357333	.2900414	.646	-.479127	.750594
		T3	.4339000	.2900414	.154	-.180960	1.048760
		T4	.3892333	.2900414	.198	-.225627	1.004094
		T5	1.1063000*	.2900414	.002	.491440	1.721160
		T6	-.1092667	.2900414	.711	-.724127	.505594
		T6	.1661000	.2900414	.575	-.448760	.780960
	T2	T0	.9728333*	.2900414	.004	.357973	1.587694
		T1	-.1357333	.2900414	.646	-.750594	.479127
		T3	.2981667	.2900414	.319	-.316694	.913027
		T4	.2535000	.2900414	.395	-.361360	.868360
		T5	.9705667*	.2900414	.004	.355706	1.585427
		T6	-.2450000	.2900414	.411	-.859860	.369860
		T6	.0303667	.2900414	.918	-.584494	.645227
	T3	T0	.6746667*	.2900414	.033	.059806	1.289527
		T1	-.4339000	.2900414	.154	-1.048760	.180960
		T2	-.2981667	.2900414	.319	-.913027	.316694
		T4	-.0446667	.2900414	.880	-.659527	.570194
		T5	.6724000*	.2900414	.034	.057540	1.287260
		T6	-.5431667	.2900414	.079	-1.158027	.071694
		T6	-.2678000	.2900414	.370	-.882660	.347060
	T4	T0	.7193333*	.2900414	.025	.104473	1.334194
		T1	-.3892333	.2900414	.198	-1.004094	.225627
		T2	-.2535000	.2900414	.395	-.868360	.361360
		T3	.0446667	.2900414	.880	-.570194	.659527
		T5	.7170667*	.2900414	.025	.102206	1.331927
		T6	-.4985000	.2900414	.105	-1.113360	.116360

		T6	-.2231333	.2900414	.453	-.837994	.391727
	T5	T0	.0022667	.2900414	.994	-.612594	.617127
		T1	-1.1063000*	.2900414	.002	-1.721160	-.491440
		T2	-.9705667*	.2900414	.004	-1.585427	-.355706
		T3	-.6724000*	.2900414	.034	-1.287260	-.057540
		T4	-.7170667*	.2900414	.025	-1.331927	-.102206
		T6	-1.2155667*	.2900414	.001	-1.830427	-.600706
		T6	-.9402000*	.2900414	.005	-1.555060	-.325340
	T6	T0	1.2178333*	.2900414	.001	.602973	1.832694
		T1	.1092667	.2900414	.711	-.505594	.724127
		T2	.2450000	.2900414	.411	-.369860	.859860
		T3	.5431667	.2900414	.079	-.071694	1.158027
		T4	.4985000	.2900414	.105	-.116360	1.113360
		T5	1.2155667*	.2900414	.001	.600706	1.830427
		T6	.2753667	.2900414	.357	-.339494	.890227
	T7	T0	.9424667*	.2900414	.005	.327606	1.557327
		T1	-.1661000	.2900414	.575	-.780960	.448760
		T2	-.0303667	.2900414	.918	-.645227	.584494
		T3	.2678000	.2900414	.370	-.347060	.882660
		T4	.2231333	.2900414	.453	-.391727	.837994
		T5	.9402000*	.2900414	.005	.325340	1.555060
		T6	-.2753667	.2900414	.357	-.890227	.339494

*. The mean difference is significant at the 0.05 level.

Table 4.15: Tukey HSD test of multiple comparisons for number of leaves

Dependent Variable: LEAVESBRANCHES

	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Tukey HSD	T0	T1	-1.333	.898	.804	-4.44	1.77
		T2	-1.333	.898	.804	-4.44	1.77
		T3	-2.000	.898	.386	-5.11	1.11
		T4	-.667	.898	.994	-3.77	2.44
		T5	.333	.898	1.000	-2.77	3.44

	T6	-3.000	.898	.062	-6.11	.11
	T6	-1.333	.898	.804	-4.44	1.77
T1	T0	1.333	.898	.804	-1.77	4.44
	T2	.000	.898	1.000	-3.11	3.11
	T3	-.667	.898	.994	-3.77	2.44
	T4	.667	.898	.994	-2.44	3.77
	T5	1.667	.898	.595	-1.44	4.77
	T6	-1.667	.898	.595	-4.77	1.44
	T6	.000	.898	1.000	-3.11	3.11
T2	T0	1.333	.898	.804	-1.77	4.44
	T1	.000	.898	1.000	-3.11	3.11
	T3	-.667	.898	.994	-3.77	2.44
	T4	.667	.898	.994	-2.44	3.77
	T5	1.667	.898	.595	-1.44	4.77
	T6	-1.667	.898	.595	-4.77	1.44
	T6	.000	.898	1.000	-3.11	3.11
T3	T0	2.000	.898	.386	-1.11	5.11
	T1	.667	.898	.994	-2.44	3.77
	T2	.667	.898	.994	-2.44	3.77
	T4	1.333	.898	.804	-1.77	4.44
	T5	2.333	.898	.225	-.77	5.44
	T6	-1.000	.898	.944	-4.11	2.11
	T6	.667	.898	.994	-2.44	3.77
T4	T0	.667	.898	.994	-2.44	3.77
	T1	-.667	.898	.994	-3.77	2.44
	T2	-.667	.898	.994	-3.77	2.44
	T3	-1.333	.898	.804	-4.44	1.77
	T5	1.000	.898	.944	-2.11	4.11
	T6	-2.333	.898	.225	-5.44	.77
	T6	-.667	.898	.994	-3.77	2.44
T5	T0	-.333	.898	1.000	-3.44	2.77
	T1	-1.667	.898	.595	-4.77	1.44
	T2	-1.667	.898	.595	-4.77	1.44
	T3	-2.333	.898	.225	-5.44	.77
	T4	-1.000	.898	.944	-4.11	2.11
	T6	-3.333*	.898	.031	-6.44	-.23

		T6	-1.667	.898	.595	-4.77	1.44
	T6	T0	3.000	.898	.062	-.11	6.11
		T1	1.667	.898	.595	-1.44	4.77
		T2	1.667	.898	.595	-1.44	4.77
		T3	1.000	.898	.944	-2.11	4.11
		T4	2.333	.898	.225	-.77	5.44
		T5	3.333*	.898	.031	.23	6.44
		T6	1.667	.898	.595	-1.44	4.77
	T7	T0	1.333	.898	.804	-1.77	4.44
		T1	.000	.898	1.000	-3.11	3.11
		T2	.000	.898	1.000	-3.11	3.11
		T3	-.667	.898	.994	-3.77	2.44
		T4	.667	.898	.994	-2.44	3.77
		T5	1.667	.898	.595	-1.44	4.77
		T6	-1.667	.898	.595	-4.77	1.44
LSD	T0	T1	-1.333	.898	.157	-3.24	.57
		T2	-1.333	.898	.157	-3.24	.57
		T3	-2.000*	.898	.041	-3.90	-.10
		T4	-.667	.898	.468	-2.57	1.24
		T5	.333	.898	.715	-1.57	2.24
		T6	-3.000*	.898	.004	-4.90	-1.10
		T6	-1.333	.898	.157	-3.24	.57
	T1	T0	1.333	.898	.157	-.57	3.24
		T2	.000	.898	1.000	-1.90	1.90
		T3	-.667	.898	.468	-2.57	1.24
		T4	.667	.898	.468	-1.24	2.57
		T5	1.667	.898	.082	-.24	3.57
		T6	-1.667	.898	.082	-3.57	.24
		T6	.000	.898	1.000	-1.90	1.90
	T2	T0	1.333	.898	.157	-.57	3.24
		T1	.000	.898	1.000	-1.90	1.90
		T3	-.667	.898	.468	-2.57	1.24
		T4	.667	.898	.468	-1.24	2.57
		T5	1.667	.898	.082	-.24	3.57
		T6	-1.667	.898	.082	-3.57	.24
		T6	.000	.898	1.000	-1.90	1.90

T3	T0	2.000*	.898	.041	.10	3.90
	T1	.667	.898	.468	-1.24	2.57
	T2	.667	.898	.468	-1.24	2.57
	T4	1.333	.898	.157	-.57	3.24
	T5	2.333*	.898	.019	.43	4.24
	T6	-1.000	.898	.282	-2.90	.90
	T6	.667	.898	.468	-1.24	2.57
T4	T0	.667	.898	.468	-1.24	2.57
	T1	-.667	.898	.468	-2.57	1.24
	T2	-.667	.898	.468	-2.57	1.24
	T3	-1.333	.898	.157	-3.24	.57
	T5	1.000	.898	.282	-.90	2.90
	T6	-2.333*	.898	.019	-4.24	-.43
	T6	-.667	.898	.468	-2.57	1.24
T5	T0	-.333	.898	.715	-2.24	1.57
	T1	-1.667	.898	.082	-3.57	.24
	T2	-1.667	.898	.082	-3.57	.24
	T3	-2.333*	.898	.019	-4.24	-.43
	T4	-1.000	.898	.282	-2.90	.90
	T6	-3.333*	.898	.002	-5.24	-1.43
	T6	-1.667	.898	.082	-3.57	.24
T6	T0	3.000*	.898	.004	1.10	4.90
	T1	1.667	.898	.082	-.24	3.57
	T2	1.667	.898	.082	-.24	3.57
	T3	1.000	.898	.282	-.90	2.90
	T4	2.333*	.898	.019	.43	4.24
	T5	3.333*	.898	.002	1.43	5.24
	T6	1.667	.898	.082	-.24	3.57
T7	T0	1.333	.898	.157	-.57	3.24
	T1	.000	.898	1.000	-1.90	1.90
	T2	.000	.898	1.000	-1.90	1.90
	T3	-.667	.898	.468	-2.57	1.24
	T4	.667	.898	.468	-1.24	2.57
	T5	1.667	.898	.082	-.24	3.57
	T6	-1.667	.898	.082	-3.57	.24

*. The mean difference is significant at the 0.05 level.

Table 4.16: Tukey HSD test of multiple comparisons for pH

Dependent Variable: pH

	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Tukey HSD	T0	T1	-.0667	.2789	1.000	-1.032	.899
		T2	-.2000	.2789	.995	-1.166	.766
		T3	.2667	.2789	.975	-.699	1.232
		T4	.0000	.2789	1.000	-.966	.966
		T5	-.1333	.2789	1.000	-1.099	.832
		T6	.0667	.2789	1.000	-.899	1.032
		T6	-.2000	.2789	.995	-1.166	.766
	T1	T0	.0667	.2789	1.000	-.899	1.032
		T2	-.1333	.2789	1.000	-1.099	.832
		T3	.3333	.2789	.922	-.632	1.299
		T4	.0667	.2789	1.000	-.899	1.032
		T5	-.0667	.2789	1.000	-1.032	.899
		T6	.1333	.2789	1.000	-.832	1.099
		T6	-.1333	.2789	1.000	-1.099	.832
	T2	T0	.2000	.2789	.995	-.766	1.166
		T1	.1333	.2789	1.000	-.832	1.099
		T3	.4667	.2789	.703	-.499	1.432
		T4	.2000	.2789	.995	-.766	1.166
		T5	.0667	.2789	1.000	-.899	1.032
		T6	.2667	.2789	.975	-.699	1.232
		T6	.0000	.2789	1.000	-.966	.966
	T3	T0	-.2667	.2789	.975	-1.232	.699
		T1	-.3333	.2789	.922	-1.299	.632
		T2	-.4667	.2789	.703	-1.432	.499
		T4	-.2667	.2789	.975	-1.232	.699
		T5	-.4000	.2789	.829	-1.366	.566
		T6	-.2000	.2789	.995	-1.166	.766
		T6	-.4667	.2789	.703	-1.432	.499

	T4	T0	.0000	.2789	1.000	-.966	.966
		T1	-.0667	.2789	1.000	-1.032	.899
		T2	-.2000	.2789	.995	-1.166	.766
		T3	.2667	.2789	.975	-.699	1.232
		T5	-.1333	.2789	1.000	-1.099	.832
		T6	.0667	.2789	1.000	-.899	1.032
		T6	-.2000	.2789	.995	-1.166	.766
	T5	T0	.1333	.2789	1.000	-.832	1.099
		T1	.0667	.2789	1.000	-.899	1.032
		T2	-.0667	.2789	1.000	-1.032	.899
		T3	.4000	.2789	.829	-.566	1.366
		T4	.1333	.2789	1.000	-.832	1.099
		T6	.2000	.2789	.995	-.766	1.166
		T6	-.0667	.2789	1.000	-1.032	.899
	T6	T0	-.0667	.2789	1.000	-1.032	.899
		T1	-.1333	.2789	1.000	-1.099	.832
		T2	-.2667	.2789	.975	-1.232	.699
		T3	.2000	.2789	.995	-.766	1.166
		T4	-.0667	.2789	1.000	-1.032	.899
		T5	-.2000	.2789	.995	-1.166	.766
		T6	-.2667	.2789	.975	-1.232	.699
	T7	T0	.2000	.2789	.995	-.766	1.166
		T1	.1333	.2789	1.000	-.832	1.099
		T2	.0000	.2789	1.000	-.966	.966
		T3	.4667	.2789	.703	-.499	1.432
		T4	.2000	.2789	.995	-.766	1.166
		T5	.0667	.2789	1.000	-.899	1.032
		T6	.2667	.2789	.975	-.699	1.232
LSD	T0	T1	-.0667	.2789	.814	-.658	.525
		T2	-.2000	.2789	.484	-.791	.391
		T3	.2667	.2789	.353	-.325	.858
		T4	.0000	.2789	1.000	-.591	.591
		T5	-.1333	.2789	.639	-.725	.458
		T6	.0667	.2789	.814	-.525	.658
		T6	-.2000	.2789	.484	-.791	.391
	T1	T0	.0667	.2789	.814	-.525	.658

		T2	-.1333	.2789	.639	-.725	.458
		T3	.3333	.2789	.249	-.258	.925
		T4	.0667	.2789	.814	-.525	.658
		T5	-.0667	.2789	.814	-.658	.525
		T6	.1333	.2789	.639	-.458	.725
		T6	-.1333	.2789	.639	-.725	.458
T2		T0	.2000	.2789	.484	-.391	.791
		T1	.1333	.2789	.639	-.458	.725
		T3	.4667	.2789	.114	-.125	1.058
		T4	.2000	.2789	.484	-.391	.791
		T5	.0667	.2789	.814	-.525	.658
		T6	.2667	.2789	.353	-.325	.858
		T6	.0000	.2789	1.000	-.591	.591
T3		T0	-.2667	.2789	.353	-.858	.325
		T1	-.3333	.2789	.249	-.925	.258
		T2	-.4667	.2789	.114	-1.058	.125
		T4	-.2667	.2789	.353	-.858	.325
		T5	-.4000	.2789	.171	-.991	.191
		T6	-.2000	.2789	.484	-.791	.391
		T6	-.4667	.2789	.114	-1.058	.125
	T4	T0	.0000	.2789	1.000	-.591	.591
		T1	-.0667	.2789	.814	-.658	.525
		T2	-.2000	.2789	.484	-.791	.391
		T3	.2667	.2789	.353	-.325	.858
		T5	-.1333	.2789	.639	-.725	.458
		T6	.0667	.2789	.814	-.525	.658
		T6	-.2000	.2789	.484	-.791	.391
T5		T0	.1333	.2789	.639	-.458	.725
		T1	.0667	.2789	.814	-.525	.658
		T2	-.0667	.2789	.814	-.658	.525
		T3	.4000	.2789	.171	-.191	.991
		T4	.1333	.2789	.639	-.458	.725
		T6	.2000	.2789	.484	-.391	.791
		T6	-.0667	.2789	.814	-.658	.525
T6		T0	-.0667	.2789	.814	-.658	.525
		T1	-.1333	.2789	.639	-.725	.458

		T2	-.2667	.2789	.353	-.858	.325
		T3	.2000	.2789	.484	-.391	.791
		T4	-.0667	.2789	.814	-.658	.525
		T5	-.2000	.2789	.484	-.791	.391
		T6	-.2667	.2789	.353	-.858	.325
	T7	T0	.2000	.2789	.484	-.391	.791
		T1	.1333	.2789	.639	-.458	.725
		T2	.0000	.2789	1.000	-.591	.591
		T3	.4667	.2789	.114	-.125	1.058
		T4	.2000	.2789	.484	-.391	.791
		T5	.0667	.2789	.814	-.525	.658
		T6	.2667	.2789	.353	-.325	.858

Table 4.17: Tukey HSD test of multiple comparisons for nitrogen

Dependent Variable: mL

	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Tukey HSD	T0	2	-4.1333*	1.0682	.025	-7.916	-.351
		3	-3.7667	1.0682	.052	-7.549	.016
		4	-3.7667	1.0682	.052	-7.549	.016
		5	-4.0667*	1.0682	.029	-7.849	-.284
		6	.1667	1.0682	1.000	-3.616	3.949
		7	-1.0333	1.0682	.991	-4.816	2.749
		8	-.8333	1.0682	.998	-4.616	2.949
		9	-.8000	1.0682	.999	-4.583	2.983
		10	-18.5333*	1.0682	.000	-22.316	-14.751
	T1	T0	4.1333*	1.0682	.025	.351	7.916
		3	.3667	1.0682	1.000	-3.416	4.149
		4	.3667	1.0682	1.000	-3.416	4.149
		5	.0667	1.0682	1.000	-3.716	3.849
		6	4.3000*	1.0682	.018	.517	8.083
		7	3.1000	1.0682	.169	-.683	6.883

	8	3.3000	1.0682	.121	-.483	7.083
	9	3.3333	1.0682	.114	-.449	7.116
	10	-14.4000*	1.0682	.000	-18.183	-10.617
T2	T0	3.7667	1.0682	.052	-.016	7.549
	2	-.3667	1.0682	1.000	-4.149	3.416
	4	.0000	1.0682	1.000	-3.783	3.783
	5	-.3000	1.0682	1.000	-4.083	3.483
	6	3.9333*	1.0682	.037	.151	7.716
	7	2.7333	1.0682	.297	-1.049	6.516
	8	2.9333	1.0682	.221	-.849	6.716
	9	2.9667	1.0682	.209	-.816	6.749
	10	-14.7667*	1.0682	.000	-18.549	-10.984
T3	T0	3.7667	1.0682	.052	-.016	7.549
	2	-.3667	1.0682	1.000	-4.149	3.416
	3	.0000	1.0682	1.000	-3.783	3.783
	5	-.3000	1.0682	1.000	-4.083	3.483
	6	3.9333*	1.0682	.037	.151	7.716
	7	2.7333	1.0682	.297	-1.049	6.516
	8	2.9333	1.0682	.221	-.849	6.716
	9	2.9667	1.0682	.209	-.816	6.749
	10	-14.7667*	1.0682	.000	-18.549	-10.984
T4	T0	4.0667*	1.0682	.029	.284	7.849
	2	-.0667	1.0682	1.000	-3.849	3.716
	3	.3000	1.0682	1.000	-3.483	4.083
	4	.3000	1.0682	1.000	-3.483	4.083
	6	4.2333*	1.0682	.021	.451	8.016
	7	3.0333	1.0682	.188	-.749	6.816
	8	3.2333	1.0682	.135	-.549	7.016
	9	3.2667	1.0682	.128	-.516	7.049
	10	-14.4667*	1.0682	.000	-18.249	-10.684
T5	T0	-.1667	1.0682	1.000	-3.949	3.616
	2	-4.3000*	1.0682	.018	-8.083	-.517
	3	-3.9333*	1.0682	.037	-7.716	-.151
	4	-3.9333*	1.0682	.037	-7.716	-.151
	5	-4.2333*	1.0682	.021	-8.016	-.451
	7	-1.2000	1.0682	.976	-4.983	2.583

	8	-1.0000	1.0682	.993	-4.783	2.783
	9	-.9667	1.0682	.994	-4.749	2.816
	10	-18.7000*	1.0682	.000	-22.483	-14.917
T6	T0	1.0333	1.0682	.991	-2.749	4.816
	2	-3.1000	1.0682	.169	-6.883	.683
	3	-2.7333	1.0682	.297	-6.516	1.049
	4	-2.7333	1.0682	.297	-6.516	1.049
	5	-3.0333	1.0682	.188	-6.816	.749
	6	1.2000	1.0682	.976	-2.583	4.983
	8	.2000	1.0682	1.000	-3.583	3.983
	9	.2333	1.0682	1.000	-3.549	4.016
	10	-17.5000*	1.0682	.000	-21.283	-13.717
T7	T0	.8333	1.0682	.998	-2.949	4.616
	2	-3.3000	1.0682	.121	-7.083	.483
	3	-2.9333	1.0682	.221	-6.716	.849
	4	-2.9333	1.0682	.221	-6.716	.849
	5	-3.2333	1.0682	.135	-7.016	.549
	6	1.0000	1.0682	.993	-2.783	4.783
	7	-.2000	1.0682	1.000	-3.983	3.583
	9	.0333	1.0682	1.000	-3.749	3.816
	10	-17.7000*	1.0682	.000	-21.483	-13.917
Biochar	T0	.8000	1.0682	.999	-2.983	4.583
	2	-3.3333	1.0682	.114	-7.116	.449
	3	-2.9667	1.0682	.209	-6.749	.816
	4	-2.9667	1.0682	.209	-6.749	.816
	5	-3.2667	1.0682	.128	-7.049	.516
	6	.9667	1.0682	.994	-2.816	4.749
	7	-.2333	1.0682	1.000	-4.016	3.549
	8	-.0333	1.0682	1.000	-3.816	3.749
	10	-17.7333*	1.0682	.000	-21.516	-13.951
Frass	T0	18.5333*	1.0682	.000	14.751	22.316
	2	14.4000*	1.0682	.000	10.617	18.183
	3	14.7667*	1.0682	.000	10.984	18.549
	4	14.7667*	1.0682	.000	10.984	18.549
	5	14.4667*	1.0682	.000	10.684	18.249
	6	18.7000*	1.0682	.000	14.917	22.483

		7	17.5000*	1.0682	.000	13.717	21.283
		8	17.7000*	1.0682	.000	13.917	21.483
		9	17.7333*	1.0682	.000	13.951	21.516
LSD	T0	2	-4.1333*	1.0682	.001	-6.362	-1.905
		3	-3.7667*	1.0682	.002	-5.995	-1.538
		4	-3.7667*	1.0682	.002	-5.995	-1.538
		5	-4.0667*	1.0682	.001	-6.295	-1.838
		6	.1667	1.0682	.878	-2.062	2.395
		7	-1.0333	1.0682	.345	-3.262	1.195
		8	-.8333	1.0682	.444	-3.062	1.395
		9	-.8000	1.0682	.463	-3.028	1.428
		10	-18.5333*	1.0682	.000	-20.762	-16.305
	T1	T0	4.1333*	1.0682	.001	1.905	6.362
		3	.3667	1.0682	.735	-1.862	2.595
		4	.3667	1.0682	.735	-1.862	2.595
		5	.0667	1.0682	.951	-2.162	2.295
		6	4.3000*	1.0682	.001	2.072	6.528
		7	3.1000*	1.0682	.009	.872	5.328
		8	3.3000*	1.0682	.006	1.072	5.528
		9	3.3333*	1.0682	.005	1.105	5.562
		10	-14.4000*	1.0682	.000	-16.628	-12.172
	T2	T0	3.7667*	1.0682	.002	1.538	5.995
		2	-.3667	1.0682	.735	-2.595	1.862
		4	.0000	1.0682	1.000	-2.228	2.228
		5	-.3000	1.0682	.782	-2.528	1.928
		6	3.9333*	1.0682	.001	1.705	6.162
		7	2.7333*	1.0682	.019	.505	4.962
		8	2.9333*	1.0682	.012	.705	5.162
		9	2.9667*	1.0682	.012	.738	5.195
		10	-14.7667*	1.0682	.000	-16.995	-12.538
	T3	T0	3.7667*	1.0682	.002	1.538	5.995
		2	-.3667	1.0682	.735	-2.595	1.862
		3	.0000	1.0682	1.000	-2.228	2.228
		5	-.3000	1.0682	.782	-2.528	1.928
		6	3.9333*	1.0682	.001	1.705	6.162
		7	2.7333*	1.0682	.019	.505	4.962

	8	2.9333*	1.0682	.012	.705	5.162
	9	2.9667*	1.0682	.012	.738	5.195
	10	-14.7667*	1.0682	.000	-16.995	-12.538
T4	T0	4.0667*	1.0682	.001	1.838	6.295
	2	-.0667	1.0682	.951	-2.295	2.162
	3	.3000	1.0682	.782	-1.928	2.528
	4	.3000	1.0682	.782	-1.928	2.528
	6	4.2333*	1.0682	.001	2.005	6.462
	7	3.0333*	1.0682	.010	.805	5.262
	8	3.2333*	1.0682	.007	1.005	5.462
	9	3.2667*	1.0682	.006	1.038	5.495
	10	-14.4667*	1.0682	.000	-16.695	-12.238
T5	T0	-.1667	1.0682	.878	-2.395	2.062
	2	-4.3000*	1.0682	.001	-6.528	-2.072
	3	-3.9333*	1.0682	.001	-6.162	-1.705
	4	-3.9333*	1.0682	.001	-6.162	-1.705
	5	-4.2333*	1.0682	.001	-6.462	-2.005
	7	-1.2000	1.0682	.275	-3.428	1.028
	8	-1.0000	1.0682	.360	-3.228	1.228
	9	-.9667	1.0682	.376	-3.195	1.262
	10	-18.7000*	1.0682	.000	-20.928	-16.472
T6	T0	1.0333	1.0682	.345	-1.195	3.262
	2	-3.1000*	1.0682	.009	-5.328	-.872
	3	-2.7333*	1.0682	.019	-4.962	-.505
	4	-2.7333*	1.0682	.019	-4.962	-.505
	5	-3.0333*	1.0682	.010	-5.262	-.805
	6	1.2000	1.0682	.275	-1.028	3.428
	8	.2000	1.0682	.853	-2.028	2.428
	9	.2333	1.0682	.829	-1.995	2.462
	10	-17.5000*	1.0682	.000	-19.728	-15.272
T7	T0	.8333	1.0682	.444	-1.395	3.062
	2	-3.3000*	1.0682	.006	-5.528	-1.072
	3	-2.9333*	1.0682	.012	-5.162	-.705
	4	-2.9333*	1.0682	.012	-5.162	-.705
	5	-3.2333*	1.0682	.007	-5.462	-1.005
	6	1.0000	1.0682	.360	-1.228	3.228

		7	-.2000	1.0682	.853	-2.428	2.028
		9	.0333	1.0682	.975	-2.195	2.262
		10	-17.7000*	1.0682	.000	-19.928	-15.472
	Biochar	T0	.8000	1.0682	.463	-1.428	3.028
		2	-3.3333*	1.0682	.005	-5.562	-1.105
		3	-2.9667*	1.0682	.012	-5.195	-.738
		4	-2.9667*	1.0682	.012	-5.195	-.738
		5	-3.2667*	1.0682	.006	-5.495	-1.038
		6	.9667	1.0682	.376	-1.262	3.195
		7	-.2333	1.0682	.829	-2.462	1.995
		8	-.0333	1.0682	.975	-2.262	2.195
		10	-17.7333*	1.0682	.000	-19.962	-15.505
	Frass	T0	18.5333*	1.0682	.000	16.305	20.762
		2	14.4000*	1.0682	.000	12.172	16.628
		3	14.7667*	1.0682	.000	12.538	16.995
		4	14.7667*	1.0682	.000	12.538	16.995
		5	14.4667*	1.0682	.000	12.238	16.695
		6	18.7000*	1.0682	.000	16.472	20.928
		7	17.5000*	1.0682	.000	15.272	19.728
		8	17.7000*	1.0682	.000	15.472	19.928
		9	17.7333*	1.0682	.000	15.505	19.962

*. The mean difference is significant at the 0.05 level.

Table 4.18: Tukey HSD test of multiple comparisons for phosphorus

Dependent Variable: PHOSPHORUS

	(I) Treatmnet	(J) Treatmnet	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Tukey HSD	T0	T1	-416.46333	300.39911	.918	-1480.2090	647.2823
		T2	-18.13000	300.39911	1.000	-1081.8756	1045.6156
		T3	187.98000	300.39911	1.000	-875.7656	1251.7256

	T4	-115.63000	300.39911	1.000	-1179.3756	948.1156
	T5	-72.76000	300.39911	1.000	-1136.5056	990.9856
	T6	-5.63000	300.39911	1.000	-1069.3756	1058.1156
	T7	-144.80000	300.39911	1.000	-1208.5456	918.9456
	Biochar	-5.35333	300.39911	1.000	-1069.0990	1058.3923
	Frass	-278.13000	300.39911	.993	-1341.8756	785.6156
T1	T0	416.46333	300.39911	.918	-647.2823	1480.2090
	T2	398.33333	300.39911	.936	-665.4123	1462.0790
	T3	604.44333	300.39911	.601	-459.3023	1668.1890
	T4	300.83333	300.39911	.989	-762.9123	1364.5790
	T5	343.70333	300.39911	.973	-720.0423	1407.4490
	T6	410.83333	300.39911	.924	-652.9123	1474.5790
	T7	271.66333	300.39911	.994	-792.0823	1335.4090
	Biochar	411.11000	300.39911	.923	-652.6356	1474.8556
	Frass	138.33333	300.39911	1.000	-925.4123	1202.0790
T2	T0	18.13000	300.39911	1.000	-1045.6156	1081.8756
	T1	-398.33333	300.39911	.936	-1462.0790	665.4123
	T3	206.11000	300.39911	.999	-857.6356	1269.8556
	T4	-97.50000	300.39911	1.000	-1161.2456	966.2456
	T5	-54.63000	300.39911	1.000	-1118.3756	1009.1156
	T6	12.50000	300.39911	1.000	-1051.2456	1076.2456
	T7	-126.67000	300.39911	1.000	-1190.4156	937.0756
	Biochar	12.77667	300.39911	1.000	-1050.9690	1076.5223
	Frass	-260.00000	300.39911	.996	-1323.7456	803.7456
T3	T0	-187.98000	300.39911	1.000	-1251.7256	875.7656
	T1	-604.44333	300.39911	.601	-1668.1890	459.3023
	T2	-206.11000	300.39911	.999	-1269.8556	857.6356
	T4	-303.61000	300.39911	.988	-1367.3556	760.1356
	T5	-260.74000	300.39911	.996	-1324.4856	803.0056
	T6	-193.61000	300.39911	1.000	-1257.3556	870.1356
	T7	-332.78000	300.39911	.978	-1396.5256	730.9656
	Biochar	-193.33333	300.39911	1.000	-1257.0790	870.4123
	Frass	-466.11000	300.39911	.855	-1529.8556	597.6356
T4	T0	115.63000	300.39911	1.000	-948.1156	1179.3756
	T1	-300.83333	300.39911	.989	-1364.5790	762.9123
	T2	97.50000	300.39911	1.000	-966.2456	1161.2456

	T3	303.61000	300.39911	.988	-760.1356	1367.3556
	T5	42.87000	300.39911	1.000	-1020.8756	1106.6156
	T6	110.00000	300.39911	1.000	-953.7456	1173.7456
	T7	-29.17000	300.39911	1.000	-1092.9156	1034.5756
	Biochar	110.27667	300.39911	1.000	-953.4690	1174.0223
	Frass	-162.50000	300.39911	1.000	-1226.2456	901.2456
T5	T0	72.76000	300.39911	1.000	-990.9856	1136.5056
	T1	-343.70333	300.39911	.973	-1407.4490	720.0423
	T2	54.63000	300.39911	1.000	-1009.1156	1118.3756
	T3	260.74000	300.39911	.996	-803.0056	1324.4856
	T4	-42.87000	300.39911	1.000	-1106.6156	1020.8756
	T6	67.13000	300.39911	1.000	-996.6156	1130.8756
	T7	-72.04000	300.39911	1.000	-1135.7856	991.7056
	Biochar	67.40667	300.39911	1.000	-996.3390	1131.1523
	Frass	-205.37000	300.39911	.999	-1269.1156	858.3756
T6	T0	5.63000	300.39911	1.000	-1058.1156	1069.3756
	T1	-410.83333	300.39911	.924	-1474.5790	652.9123
	T2	-12.50000	300.39911	1.000	-1076.2456	1051.2456
	T3	193.61000	300.39911	1.000	-870.1356	1257.3556
	T4	-110.00000	300.39911	1.000	-1173.7456	953.7456
	T5	-67.13000	300.39911	1.000	-1130.8756	996.6156
	T7	-139.17000	300.39911	1.000	-1202.9156	924.5756
	Biochar	.27667	300.39911	1.000	-1063.4690	1064.0223
	Frass	-272.50000	300.39911	.994	-1336.2456	791.2456
T7	T0	144.80000	300.39911	1.000	-918.9456	1208.5456
	T1	-271.66333	300.39911	.994	-1335.4090	792.0823
	T2	126.67000	300.39911	1.000	-937.0756	1190.4156
	T3	332.78000	300.39911	.978	-730.9656	1396.5256
	T4	29.17000	300.39911	1.000	-1034.5756	1092.9156
	T5	72.04000	300.39911	1.000	-991.7056	1135.7856
	T6	139.17000	300.39911	1.000	-924.5756	1202.9156
	Biochar	139.44667	300.39911	1.000	-924.2990	1203.1923
	Frass	-133.33000	300.39911	1.000	-1197.0756	930.4156
Biochar	T0	5.35333	300.39911	1.000	-1058.3923	1069.0990
	T1	-411.11000	300.39911	.923	-1474.8556	652.6356
	T2	-12.77667	300.39911	1.000	-1076.5223	1050.9690

		T3	193.33333	300.39911	1.000	-870.4123	1257.0790
		T4	-110.27667	300.39911	1.000	-1174.0223	953.4690
		T5	-67.40667	300.39911	1.000	-1131.1523	996.3390
		T6	-.27667	300.39911	1.000	-1064.0223	1063.4690
		T7	-139.44667	300.39911	1.000	-1203.1923	924.2990
		Frass	-272.77667	300.39911	.994	-1336.5223	790.9690
	Frass	T0	278.13000	300.39911	.993	-785.6156	1341.8756
		T1	-138.33333	300.39911	1.000	-1202.0790	925.4123
		T2	260.00000	300.39911	.996	-803.7456	1323.7456
		T3	466.11000	300.39911	.855	-597.6356	1529.8556
		T4	162.50000	300.39911	1.000	-901.2456	1226.2456
		T5	205.37000	300.39911	.999	-858.3756	1269.1156
		T6	272.50000	300.39911	.994	-791.2456	1336.2456
		T7	133.33000	300.39911	1.000	-930.4156	1197.0756
		Biochar	272.77667	300.39911	.994	-790.9690	1336.5223
LSD	T0	T1	-416.46333	300.39911	.181	-1043.0849	210.1582
		T2	-18.13000	300.39911	.952	-644.7516	608.4916
		T3	187.98000	300.39911	.539	-438.6416	814.6016
		T4	-115.63000	300.39911	.704	-742.2516	510.9916
		T5	-72.76000	300.39911	.811	-699.3816	553.8616
		T6	-5.63000	300.39911	.985	-632.2516	620.9916
		T7	-144.80000	300.39911	.635	-771.4216	481.8216
		Biochar	-5.35333	300.39911	.986	-631.9749	621.2682
		Frass	-278.13000	300.39911	.366	-904.7516	348.4916
	T1	T0	416.46333	300.39911	.181	-210.1582	1043.0849
		T2	398.33333	300.39911	.200	-228.2882	1024.9549
		T3	604.44333	300.39911	.058	-22.1782	1231.0649
		T4	300.83333	300.39911	.329	-325.7882	927.4549
		T5	343.70333	300.39911	.266	-282.9182	970.3249
		T6	410.83333	300.39911	.187	-215.7882	1037.4549
		T7	271.66333	300.39911	.377	-354.9582	898.2849
		Biochar	411.11000	300.39911	.186	-215.5116	1037.7316
		Frass	138.33333	300.39911	.650	-488.2882	764.9549
	T2	T0	18.13000	300.39911	.952	-608.4916	644.7516
		T1	-398.33333	300.39911	.200	-1024.9549	228.2882
		T3	206.11000	300.39911	.501	-420.5116	832.7316

	T4	-97.50000	300.39911	.749	-724.1216	529.1216
	T5	-54.63000	300.39911	.858	-681.2516	571.9916
	T6	12.50000	300.39911	.967	-614.1216	639.1216
	T7	-126.67000	300.39911	.678	-753.2916	499.9516
	Biochar	12.77667	300.39911	.966	-613.8449	639.3982
	Frass	-260.00000	300.39911	.397	-886.6216	366.6216
T3	T0	-187.98000	300.39911	.539	-814.6016	438.6416
	T1	-604.44333	300.39911	.058	-1231.0649	22.1782
	T2	-206.11000	300.39911	.501	-832.7316	420.5116
	T4	-303.61000	300.39911	.324	-930.2316	323.0116
	T5	-260.74000	300.39911	.396	-887.3616	365.8816
	T6	-193.61000	300.39911	.527	-820.2316	433.0116
	T7	-332.78000	300.39911	.281	-959.4016	293.8416
	Biochar	-193.33333	300.39911	.527	-819.9549	433.2882
	Frass	-466.11000	300.39911	.136	-1092.7316	160.5116
T4	T0	115.63000	300.39911	.704	-510.9916	742.2516
	T1	-300.83333	300.39911	.329	-927.4549	325.7882
	T2	97.50000	300.39911	.749	-529.1216	724.1216
	T3	303.61000	300.39911	.324	-323.0116	930.2316
	T5	42.87000	300.39911	.888	-583.7516	669.4916
	T6	110.00000	300.39911	.718	-516.6216	736.6216
	T7	-29.17000	300.39911	.924	-655.7916	597.4516
	Biochar	110.27667	300.39911	.717	-516.3449	736.8982
	Frass	-162.50000	300.39911	.595	-789.1216	464.1216
T5	T0	72.76000	300.39911	.811	-553.8616	699.3816
	T1	-343.70333	300.39911	.266	-970.3249	282.9182
	T2	54.63000	300.39911	.858	-571.9916	681.2516
	T3	260.74000	300.39911	.396	-365.8816	887.3616
	T4	-42.87000	300.39911	.888	-669.4916	583.7516
	T6	67.13000	300.39911	.825	-559.4916	693.7516
	T7	-72.04000	300.39911	.813	-698.6616	554.5816
	Biochar	67.40667	300.39911	.825	-559.2149	694.0282
	Frass	-205.37000	300.39911	.502	-831.9916	421.2516
T6	T0	5.63000	300.39911	.985	-620.9916	632.2516
	T1	-410.83333	300.39911	.187	-1037.4549	215.7882
	T2	-12.50000	300.39911	.967	-639.1216	614.1216

	T3	193.61000	300.39911	.527	-433.0116	820.2316
	T4	-110.00000	300.39911	.718	-736.6216	516.6216
	T5	-67.13000	300.39911	.825	-693.7516	559.4916
	T7	-139.17000	300.39911	.648	-765.7916	487.4516
	Biochar	.27667	300.39911	.999	-626.3449	626.8982
	Frass	-272.50000	300.39911	.375	-899.1216	354.1216
T7	T0	144.80000	300.39911	.635	-481.8216	771.4216
	T1	-271.66333	300.39911	.377	-898.2849	354.9582
	T2	126.67000	300.39911	.678	-499.9516	753.2916
	T3	332.78000	300.39911	.281	-293.8416	959.4016
	T4	29.17000	300.39911	.924	-597.4516	655.7916
	T5	72.04000	300.39911	.813	-554.5816	698.6616
	T6	139.17000	300.39911	.648	-487.4516	765.7916
	Biochar	139.44667	300.39911	.648	-487.1749	766.0682
	Frass	-133.33000	300.39911	.662	-759.9516	493.2916
Biochar	T0	5.35333	300.39911	.986	-621.2682	631.9749
	T1	-411.11000	300.39911	.186	-1037.7316	215.5116
	T2	-12.77667	300.39911	.966	-639.3982	613.8449
	T3	193.33333	300.39911	.527	-433.2882	819.9549
	T4	-110.27667	300.39911	.717	-736.8982	516.3449
	T5	-67.40667	300.39911	.825	-694.0282	559.2149
	T6	-.27667	300.39911	.999	-626.8982	626.3449
	T7	-139.44667	300.39911	.648	-766.0682	487.1749
	Frass	-272.77667	300.39911	.375	-899.3982	353.8449
Frass	T0	278.13000	300.39911	.366	-348.4916	904.7516
	T1	-138.33333	300.39911	.650	-764.9549	488.2882
	T2	260.00000	300.39911	.397	-366.6216	886.6216
	T3	466.11000	300.39911	.136	-160.5116	1092.7316
	T4	162.50000	300.39911	.595	-464.1216	789.1216
	T5	205.37000	300.39911	.502	-421.2516	831.9916
	T6	272.50000	300.39911	.375	-354.1216	899.1216
	T7	133.33000	300.39911	.662	-493.2916	759.9516
	Biochar	272.77667	300.39911	.375	-353.8449	899.3982

Table 4.19: Tukey HSD test of multiple comparisons for potassium

Dependent Variable: Potassium in ppm

	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Tukey HSD	T0	T1	-197666.667	116121.488	.782	-608865.37	213532.04
		T2	-41000.000	116121.488	1.000	-452198.71	370198.71
		T3	-111000.000	116121.488	.992	-522198.71	300198.71
		T4	-407666.667	116121.488	.053	-818865.37	3532.04
		T5	-34333.333	116121.488	1.000	-445532.04	376865.37
		T6	-87666.667	116121.488	.999	-498865.37	323532.04
		T7	-144333.333	116121.488	.955	-555532.04	266865.37
		Biochar	-377666.667	116121.488	.089	-788865.37	33532.04
		Frass	-781000.000*	116121.488	.000	-1192198.71	-369801.29
	T1	T0	197666.667	116121.488	.782	-213532.04	608865.37
		T2	156666.667	116121.488	.929	-254532.04	567865.37
		T3	86666.667	116121.488	.999	-324532.04	497865.37
		T4	-210000.000	116121.488	.723	-621198.71	201198.71
		T5	163333.333	116121.488	.911	-247865.37	574532.04
		T6	110000.000	116121.488	.992	-301198.71	521198.71
		T7	53333.333	116121.488	1.000	-357865.37	464532.04
		Biochar	-180000.000	116121.488	.856	-591198.71	231198.71
		Frass	-583333.333*	116121.488	.002	-994532.04	-172134.63
	T2	T0	41000.000	116121.488	1.000	-370198.71	452198.71
		T1	-156666.667	116121.488	.929	-567865.37	254532.04
		T3	-70000.000	116121.488	1.000	-481198.71	341198.71
		T4	-366666.667	116121.488	.106	-777865.37	44532.04
		T5	6666.667	116121.488	1.000	-404532.04	417865.37
		T6	-46666.667	116121.488	1.000	-457865.37	364532.04
		T7	-103333.333	116121.488	.995	-514532.04	307865.37
		Biochar	-336666.667	116121.488	.170	-747865.37	74532.04
		Frass	-740000.000*	116121.488	.000	-1151198.71	-328801.29
	T3	T0	111000.000	116121.488	.992	-300198.71	522198.71
		T1	-86666.667	116121.488	.999	-497865.37	324532.04
		T2	70000.000	116121.488	1.000	-341198.71	481198.71
		T4	-296666.667	116121.488	.299	-707865.37	114532.04
		T5	76666.667	116121.488	.999	-334532.04	487865.37

	T6	23333.333	116121.488	1.000	-387865.37	434532.04
	T7	-33333.333	116121.488	1.000	-444532.04	377865.37
	Biochar	-266666.667	116121.488	.431	-677865.37	144532.04
	Frass	-670000.000*	116121.488	.000	-1081198.71	-258801.29
T4	T0	407666.667	116121.488	.053	-3532.04	818865.37
	T1	210000.000	116121.488	.723	-201198.71	621198.71
	T2	366666.667	116121.488	.106	-44532.04	777865.37
	T3	296666.667	116121.488	.299	-114532.04	707865.37
	T5	373333.333	116121.488	.095	-37865.37	784532.04
	T6	320000.000	116121.488	.217	-91198.71	731198.71
	T7	263333.333	116121.488	.448	-147865.37	674532.04
	Biochar	30000.000	116121.488	1.000	-381198.71	441198.71
	Frass	-373333.333	116121.488	.095	-784532.04	37865.37
T5	T0	34333.333	116121.488	1.000	-376865.37	445532.04
	T1	-163333.333	116121.488	.911	-574532.04	247865.37
	T2	-6666.667	116121.488	1.000	-417865.37	404532.04
	T3	-76666.667	116121.488	.999	-487865.37	334532.04
	T4	-373333.333	116121.488	.095	-784532.04	37865.37
	T6	-53333.333	116121.488	1.000	-464532.04	357865.37
	T7	-110000.000	116121.488	.992	-521198.71	301198.71
	Biochar	-343333.333	116121.488	.153	-754532.04	67865.37
	Frass	-746666.667*	116121.488	.000	-1157865.37	-335467.96
T6	T0	87666.667	116121.488	.999	-323532.04	498865.37
	T1	-110000.000	116121.488	.992	-521198.71	301198.71
	T2	46666.667	116121.488	1.000	-364532.04	457865.37
	T3	-23333.333	116121.488	1.000	-434532.04	387865.37
	T4	-320000.000	116121.488	.217	-731198.71	91198.71
	T5	53333.333	116121.488	1.000	-357865.37	464532.04
	T7	-56666.667	116121.488	1.000	-467865.37	354532.04
	Biochar	-290000.000	116121.488	.326	-701198.71	121198.71
	Frass	-693333.333*	116121.488	.000	-1104532.04	-282134.63
T7	T0	144333.333	116121.488	.955	-266865.37	555532.04
	T1	-53333.333	116121.488	1.000	-464532.04	357865.37
	T2	103333.333	116121.488	.995	-307865.37	514532.04
	T3	33333.333	116121.488	1.000	-377865.37	444532.04
	T4	-263333.333	116121.488	.448	-674532.04	147865.37

		T5	110000.000	116121.488	.992	-301198.71	521198.71
		T6	56666.667	116121.488	1.000	-354532.04	467865.37
		Biochar	-233333.333	116121.488	.603	-644532.04	177865.37
		Frass	-636666.667*	116121.488	.001	-1047865.37	-225467.96
	Biochar	T0	377666.667	116121.488	.089	-33532.04	788865.37
		T1	180000.000	116121.488	.856	-231198.71	591198.71
		T2	336666.667	116121.488	.170	-74532.04	747865.37
		T3	266666.667	116121.488	.431	-144532.04	677865.37
		T4	-30000.000	116121.488	1.000	-441198.71	381198.71
		T5	343333.333	116121.488	.153	-67865.37	754532.04
		T6	290000.000	116121.488	.326	-121198.71	701198.71
		T7	233333.333	116121.488	.603	-177865.37	644532.04
		Frass	-403333.333	116121.488	.057	-814532.04	7865.37
	Frass	T0	781000.000*	116121.488	.000	369801.29	1192198.71
		T1	583333.333*	116121.488	.002	172134.63	994532.04
		T2	740000.000*	116121.488	.000	328801.29	1151198.71
		T3	670000.000*	116121.488	.000	258801.29	1081198.71
		T4	373333.333	116121.488	.095	-37865.37	784532.04
		T5	746666.667*	116121.488	.000	335467.96	1157865.37
		T6	693333.333*	116121.488	.000	282134.63	1104532.04
		T7	636666.667*	116121.488	.001	225467.96	1047865.37
		Biochar	403333.333	116121.488	.057	-7865.37	814532.04
LSD	T0	T1	-197666.667	116121.488	.104	-439891.85	44558.51
		T2	-41000.000	116121.488	.728	-283225.18	201225.18
		T3	-111000.000	116121.488	.351	-353225.18	131225.18
		T4	-407666.667*	116121.488	.002	-649891.85	-165441.49
		T5	-34333.333	116121.488	.771	-276558.51	207891.85
		T6	-87666.667	116121.488	.459	-329891.85	154558.51
		T7	-144333.333	116121.488	.228	-386558.51	97891.85
		Biochar	-377666.667*	116121.488	.004	-619891.85	-135441.49
		Frass	-781000.000*	116121.488	.000	-1023225.18	-538774.82
	T1	T0	197666.667	116121.488	.104	-44558.51	439891.85
		T2	156666.667	116121.488	.192	-85558.51	398891.85
		T3	86666.667	116121.488	.464	-155558.51	328891.85
		T4	-210000.000	116121.488	.086	-452225.18	32225.18
		T5	163333.333	116121.488	.175	-78891.85	405558.51

	T6	110000.000	116121.488	.355	-132225.18	352225.18
	T7	53333.333	116121.488	.651	-188891.85	295558.51
	Biochar	-180000.000	116121.488	.137	-422225.18	62225.18
	Frass	-583333.333*	116121.488	.000	-825558.51	-341108.15
T2	T0	41000.000	116121.488	.728	-201225.18	283225.18
	T1	-156666.667	116121.488	.192	-398891.85	85558.51
	T3	-70000.000	116121.488	.553	-312225.18	172225.18
	T4	-366666.667*	116121.488	.005	-608891.85	-124441.49
	T5	6666.667	116121.488	.955	-235558.51	248891.85
	T6	-46666.667	116121.488	.692	-288891.85	195558.51
	T7	-103333.333	116121.488	.384	-345558.51	138891.85
	Biochar	-336666.667*	116121.488	.009	-578891.85	-94441.49
	Frass	-740000.000*	116121.488	.000	-982225.18	-497774.82
T3	T0	111000.000	116121.488	.351	-131225.18	353225.18
	T1	-86666.667	116121.488	.464	-328891.85	155558.51
	T2	70000.000	116121.488	.553	-172225.18	312225.18
	T4	-296666.667*	116121.488	.019	-538891.85	-54441.49
	T5	76666.667	116121.488	.517	-165558.51	318891.85
	T6	23333.333	116121.488	.843	-218891.85	265558.51
	T7	-33333.333	116121.488	.777	-275558.51	208891.85
	Biochar	-266666.667*	116121.488	.033	-508891.85	-24441.49
	Frass	-670000.000*	116121.488	.000	-912225.18	-427774.82
T4	T0	407666.667*	116121.488	.002	165441.49	649891.85
	T1	210000.000	116121.488	.086	-32225.18	452225.18
	T2	366666.667*	116121.488	.005	124441.49	608891.85
	T3	296666.667*	116121.488	.019	54441.49	538891.85
	T5	373333.333*	116121.488	.004	131108.15	615558.51
	T6	320000.000*	116121.488	.012	77774.82	562225.18
	T7	263333.333*	116121.488	.035	21108.15	505558.51
	Biochar	30000.000	116121.488	.799	-212225.18	272225.18
	Frass	-373333.333*	116121.488	.004	-615558.51	-131108.15
T5	T0	34333.333	116121.488	.771	-207891.85	276558.51
	T1	-163333.333	116121.488	.175	-405558.51	78891.85
	T2	-6666.667	116121.488	.955	-248891.85	235558.51
	T3	-76666.667	116121.488	.517	-318891.85	165558.51
	T4	-373333.333*	116121.488	.004	-615558.51	-131108.15

	T6	-53333.333	116121.488	.651	-295558.51	188891.85
	T7	-110000.000	116121.488	.355	-352225.18	132225.18
	Biochar	-343333.333*	116121.488	.008	-585558.51	-101108.15
	Frass	-746666.667*	116121.488	.000	-988891.85	-504441.49
T6	T0	87666.667	116121.488	.459	-154558.51	329891.85
	T1	-110000.000	116121.488	.355	-352225.18	132225.18
	T2	46666.667	116121.488	.692	-195558.51	288891.85
	T3	-23333.333	116121.488	.843	-265558.51	218891.85
	T4	-320000.000*	116121.488	.012	-562225.18	-77774.82
	T5	53333.333	116121.488	.651	-188891.85	295558.51
	T7	-56666.667	116121.488	.631	-298891.85	185558.51
	Biochar	-290000.000*	116121.488	.021	-532225.18	-47774.82
	Frass	-693333.333*	116121.488	.000	-935558.51	-451108.15
T7	T0	144333.333	116121.488	.228	-97891.85	386558.51
	T1	-53333.333	116121.488	.651	-295558.51	188891.85
	T2	103333.333	116121.488	.384	-138891.85	345558.51
	T3	33333.333	116121.488	.777	-208891.85	275558.51
	T4	-263333.333*	116121.488	.035	-505558.51	-21108.15
	T5	110000.000	116121.488	.355	-132225.18	352225.18
	T6	56666.667	116121.488	.631	-185558.51	298891.85
	Biochar	-233333.333	116121.488	.058	-475558.51	8891.85
	Frass	-636666.667*	116121.488	.000	-878891.85	-394441.49
Biochar	T0	377666.667*	116121.488	.004	135441.49	619891.85
	T1	180000.000	116121.488	.137	-62225.18	422225.18
	T2	336666.667*	116121.488	.009	94441.49	578891.85
	T3	266666.667*	116121.488	.033	24441.49	508891.85
	T4	-30000.000	116121.488	.799	-272225.18	212225.18
	T5	343333.333*	116121.488	.008	101108.15	585558.51
	T6	290000.000*	116121.488	.021	47774.82	532225.18
	T7	233333.333	116121.488	.058	-8891.85	475558.51
	Frass	-403333.333*	116121.488	.002	-645558.51	-161108.15
Frass	T0	781000.000*	116121.488	.000	538774.82	1023225.18
	T1	583333.333*	116121.488	.000	341108.15	825558.51
	T2	740000.000*	116121.488	.000	497774.82	982225.18
	T3	670000.000*	116121.488	.000	427774.82	912225.18
	T4	373333.333*	116121.488	.004	131108.15	615558.51

	T5	746666.667*	116121.488	.000	504441.49	988891.85
	T6	693333.333*	116121.488	.000	451108.15	935558.51
	T7	636666.667*	116121.488	.000	394441.49	878891.85
	Biochar	403333.333*	116121.488	.002	161108.15	645558.51

*. The mean difference is significant at the 0.05 level.

Table 4.20: ANOVA test results for height of plant

ANOVA

Height in cm

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	257.112	7	36.730	7.540	.000
Within Groups	77.947	16	4.872		
Total	335.058	23			

Table 4.21: ANOVA test results for fresh weight of plant

ANOVA

Weight in g

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	745.589	7	106.513	6.232	.001
Within Groups	273.475	16	17.092		
Total	1019.064	23			

Table 4.22: ANOVA test results for dry weight of plant

ANOVA

Weight in g

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.638	7	.663	5.251	.003
Within Groups	2.019	16	.126		
Total	6.657	23			

Table 4.23: ANOVA test results for number of leaves of plant

ANOVA

LEAVES

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24.000	7	3.429	2.837	.040
Within Groups	19.333	16	1.208		
Total	43.333	23			

Table 4.24: ANOVA test results for pH of plant

ANOVA

pH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.507	7	.072	.620	.732
Within Groups	1.867	16	.117		
Total	2.373	23			

Table 4.25: ANOVA test results for nitrogen content in soil sample

ANOVA

Nitrogen content, mL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	818.200	9	90.911	53.113	.000
Within Groups	34.233	20	1.712		
Total	852.434	29			

Table 4.26: ANOVA test results for phosphorus content in soil sample

ANOVA

PHOSPHORUS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	751959.823	9	83551.091	.617	.769
Within Groups	2707188.824	20	135359.441		
Total	3459148.647	29			

Table 4.27: ANOVA test results for potassium content in soil sample

ANOVA

Potassium in ppm

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1575893366666.667	9	175099262962.963	8.657	.000
Within Groups	404526000000.000	20	20226300000.000		
Total	1980419366666.667	29			

Table 4.28: Average plant growth in the interval of 2 days

Day / T	T0 (cm)	T1 (cm)	T2 (cm)	T3 (cm)	T4 (cm)	T5 (cm)	T6 (cm)	T7 (cm)
10/12	3.53	2.7	2.8	2.2	3.2	3	3.5	2.5
12/12	4.6	4.4	3.4	2.8	4.1	3.3	3.7	3.5
14/12	4.6	6.2	4.9	3.7	6	3.9	5.3	4.6
16/12	4.9	8	6.7	4.1	6.8	4.4	6.6	6.6
18/12	5.5	8.7	7.2	6.8	8.1	5.2	9	7.1
20/12	6	9	8.5	6.6	7.3	5.5	10	7.3
22/12	6.3	9.7	9.3	7.4	8.7	4.9	10.9	9.9
24/12	6.5	9.3	10.9	9	9.4	5.1	10.7	12.1
26/12	6.6	10.1	12.5	9	9.8	5.8	13.3	13.5
28/12	6.8	13.1	14.4	10.7	12.5	6	15.1	14.3