EFFECT OF FERMENTED FRUIT JUICE (FFJ) AND FERMENTED PLANT JUICE (FPJ) ON GROWTH PERFORMANCE OF HALIA BENTONG (*Zingiber officinale* Roscoe) USING BENCH FERTIGATION SYSTEM

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A Thesis Submitted in Fulfillment of the Requirements for Degree of Bachelor of Applied Science (Agrotechnology) with Honours

UNIVERSITI MALAYSIA KELANTAN

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DECLARATION

I declare that this thesis entitled "Effect of Fermented Fruit Juice (FFJ) and Fermented Plant Juice (FPJ) on Growth Performance of *Zingiber officinale* Roscoe Using Bench Fertigation System" is the results of my own research except as cited in the references.

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Effect of Fermented Fruit Juice (FFJ) and Fermented Plant Juice (FPJ) on Growth Performance of *Halia Bentong* (*Zingiber officinale* Roscoe) Using Bench Fertigation System

ABSTRACT

Zingiber officinale Roscoe also known as Halia Bentong is one of the popular medicinal plants. Conventional cultivation techniques were often used in ginger cultivation in Malaysia. Soil diseases were major issue in an agriculture and result in widespread land use. Futhermore, excessive post -harvest waste is another environmental issue that must be addressed. As a result, an experiment was carried out to investigate the effect of organic fertilizer which are Fermented Plant Juice (FPJ) and Fermented Fruit Juice (FFJ) versus AB fertilizer on the growth and development of Halia Bentong. This experiment aims to promote reduction of land use problems as well as pollution by using soilless bench fertigation (a mixture of paddy husk and cocopeat). Ginger cultivation through fertigation system can overcome soil infertility and protect against soil -borne diseases. Throughout the 8 weeks of planting, plant height, number of leaves, number of tillers, and average whole plant weight were observed and recorded. To determine the best fertilizer application, the mean value of each parameter of Halia Bentong growth was recorded and calculated. Complete randomized design (CRD) was used in this experiment. Total of 24 samples were tested for Halia Bentong cultivation, with 12 samples as control (using AB fertilizer) and 12 samples as treatments (FFJ and FPJ). The data were analized and recorded using one -way ANOVA and the Tukey Test was used to compare the mean between treatments at a significance level of 5%. The study's findings revealed that using organic fertilizer (FPJ and FFJ) as additional booster can improve the growth performance of Halia Bentong when compared to using only AB fertilizer (24.44 ± 4.08 for Plant height; 5.64 ± 0.32 for number of leaves; 1.32 ± 0.12 for number of tiller). As a result, organic fertilizers (FPJ and FFJ) were recommended for Halia Bentong cultivation.

Keywords: Halia Bentong (*Zingiber officinale* Roscoe), FPJ (Fermented Plant Juice), FFJ (Fermented Fruit Juice), bench fertigation.

Kesan Jus Fermentasi Buah-buahan (FFJ) dan Jus Fermentasi Tanaman (FPJ) Terhadap Prestasi Pertumbuhan Halia Bentong (*Zingiber officinale* Roscoe) Menggunakan Sistem Fertigasi Meja

ABSTRAK

Zingiber officinale Roscoe juga dikenali sebagai Halia Bentong merupakan salah satu tumbuhan ubatan yang popular. Walau bagaimanapun, teknik penanaman secara konvensional sering digunakan dalam penanaman halia di Malaysia. Penyakit bawaan tanah merupakan isu utama dan mengakibatkan penggunaan tanah yang meluas. Selain itu, masalah alam sekitar yang disebabkan oleh sisa lepas tuai yang berlebihan mesti ditangani. Hasilnya, satu eksperimen telah dijalankan untuk menyiasat kesan baja organik iaitu Fermentasi Jus Tanaman (FPJ) dan Fermentasi Jus Buah-buahan (FFJ) berbanding baja AB terhadap pertumbuhan dan perkembangan Halia Bentong. Eksperimen ini bertujuan untuk mengurangkan masalah guna tanah serta pencemaran dengan menggunakan fertigasi meja tanpa tanah (campuran sekam padi + sabut kelapa). Penanaman halia dengan sistem fertigasi dapat mengatasi ketidaksuburan tanah dan melindungi daripada penyakit bawaan tanah. Sepanjang 8 minggu penanaman, ketinggian tumbuhan, bilangan daun, bilangan anak benih, dan purata berat keseluruhan tumbuhan diperhatikan dan direkodkan. Bagi menentukan penggunaan baja yang terbaik, nilai min bagi setiap parameter pertumbuhan Halia Bentong direkodkan dan dianalisa. Reka bentuk rawak lengkap (CRD) telah digunakan dalam eksperimen ini. Sebanyak 24 sampel telah diuji untuk penanaman Halia Bentong, dengan 12 sampel sebagai kawalan (baja AB) dan 12 sampel sebagai rawatan (FFJ dan FPJ). Data yang dikumpul dikira dan direkodkan menggunakan ANOVA sehala dan Ujian Tukey digunakan untuk membandingkan min antara rawatan pada aras keertian 5%. Dapatan kajian mendedahkan bahawa penggunaan baja organik (FPJ dan FFJ) sebagai penggalak tambahan boleh meningkatkan prestasi pertumbuhan Halia Bentong jika dibandingkan dengan hanya menggunakan baja AB (24.44 ± 4.08 untuk ketinggian tumbuhan; 5.64 ± 0.32 untuk bilangan daun; 1.32 ± 0.12 untuk bilangan anak benih). Hasilnya, baja organik (FPJ dan FFJ) disyorkan untuk penanaman Halia Bentong.

Kata kunci: Halia Bentong (*Zingiber officinale* Roscoe), FPJ (Fermentasi Jus Tumbuhan), FFJ (Fermentasi Jus Buah-buahan), fertigasi bangku

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LIST OF ABBREVIATIONS

FPJ	Fermented Plant Juice
FFJ	Fermented Fruit Juice
ANOVA	Analysis of Variance
SPSS	Statistical package for social science
CRD	Complete randomise design
N	Nitrogen
P	Phosphorus
K	Potassium
TNAU	Tamil Nadu Agricultural University
PVC	Polyvinyl chloride
EC	Electrical conductivity
MARDI	Malaysian Agricultural Research and Development Institute
HSD	Honestly Significant Difference
UMK	University Malaysia Kelantan

LIST OF SYMBOLS

°C	Degree Celsius
%	Percentage
±	Plus Minus
≤	Less than or equal to
µS	Micro-Siemens
µ	Micro
cm	Centimetre
kg	Kilogram
pH	Potential of hydrogen
mm	Millimetre

CHAPTER 1

INTRODUCTION

1.1 Research Background

One of the most well-known spices nowadays was Halia Bentong (*Zingiber officinale* Roscoe). According to Stoner, G.D. (2013), among other chemical constituents, *Z. officinale* contains a lot of phenolic compounds, such as terpenes, polysaccharides, lipids, organic acids, and crude fibre. *Z. officinale* has a wide range of therapeutic applications (Han, Y.A et al., 2013). The phenolic compounds in *Z. officinale*, such as gingerols and shogaols, are primarily responsible for its health benefits. *Z. officinale* contains a variety of biological effects, including antioxidant, anti-inflammatory, antibacterial, anticancer, cardiovascular, respiratory, anti-obesity, antidiabetic, antinausea, and antiemetic action, according to research by (Ghasemzadeh, A & Jaafar, H.Z., 2011).

The soil cultivation system was the most popular rhizome plant cultivation system. In this system, among the most important factors influencing plant fertility are soil aeration, water content, and nutrient content (Glinski & Stepniewski, 1985; Hillel, 1998). However, environmental issues have existed due to the cultivation system involving excessive land use resulting in wastage occurring. Nowadays, *Z. officinale* can be grown without soil due to advances in cultivation systems.

Land conservation that exists directly has benefited the environment when use soilless cultivation is in practice. This conservation exists when an area of cultivated land was used repeatedly and directly protects plants from soil -borne diseases and infertile soil issues can be avoided. Fertigation is one of the effective soilless cultivation systems which have shown increased yield and plant growth. Moreover, these fertigation systems have been in high demand and grown significantly over the years. Significant yield increases contribute to the growing interest in studying crop yield and growth when using fertigation systems (Yaseer et al., 2016).

Furthermore, according to Mastouri et al. (2005) soil-based cultivation systems are difficult to manage compared to soil-less cultivation systems which may offer a better growth environment and were easier to manage. In addition, fertigation systems also have other advantages such as the ability to control pH and nutrient concentrations in the root zone, as well as water availability (Epstein & Bloom., 2005). Now due to advancement in agriculture technology, many farmers are able to grow *Z. officinale* without soil. Suitable soil-less planting media and often use to replace soil such as burnt paddy husk, coco peat, and sawdust. According to Ortega et al. (1996), he suggested that burnt paddy husk and coco peat are examples of popular and readily available media at low prices. Therefore, the media used in this study were paddy husk and coco peat as planting media for *Z. officinale*.

1.2 Problem Statement

In ginger crops such as *Z. officinale*, soil-borne diseases caused by bacteria and fungi such as nematodes and Verticillium are common and making local farmers less interested in cultivating this type of rhizome. Furthermore, fertigation systems such as hanging fertigation cause issues such as dangerous occurrences when using pesticides and farmers having to prune using ladders. The structure for hanging fertigation can collapse and endanger the operator if it is not strong enough. The bench fertigation system will provide more space for rhizome development thus increasing the yield. Increased ginger yields may entice farmers to begin ginger cultivation. Identifying the suitable of FPJ and FFJ as booster, will promote recycling of agriculture waste as well as reducing the environmental problems caused by excessive post -harvest waste.

1.3 Hypothesis

H0: There is no significant effect on the growth and development of *Zingiber officinale* Roscoe sprayed with the Fermented Fruit Juice (FFJ) and Fermented Plant Juice (FPJ) as booster.

HA: There is significant effect on the growth and development of *Zingiber officinale* Roscoe sprayed with the Fermented Fruit Juice (FFJ) and Fermented Plant Juice (FPJ) as booster.

1.4 Objective

1. To observe the effect of soilless media containing mixture of coco peat and paddy husk on the growth and development of *Zingiber officinale* Roscoe cultivated by using bench fertigation system.
2. To recycle a post-harvest waste into plant booster that is beneficial for crops.
3. To determine effect of Fermented Fruit Juice (FFJ) and Fermented Plant Juice (FPJ) as booster on growth of *Zingiber officinale* Roscoe.

1.5 Scope of Study

This study focused on the evaluation of *Z. officinale* growth and development by utilizing the bench fertigation system using soilless media. The growth characteristic of *Z. officinale* in terms of plant height, number of leaves, number of tillers and the fresh plant weight of *Z. officinale* were observed after 3 to 8 weeks being relocated into the planting bench. The effectiveness of using plant booster from agriculture waste such as over ripen/over matured fruit on shelf and vegetables that have withered and not fresh that cannot be sold were the ingredients in making of Fermented Fruit Juice (FFJ) and Fermented Plant Juice (FPJ) on *Z. officinale* growth was also observed.

1.6 Limitation of Study

This study looks at the bench fertigation system was used to cultivate Halia Bentong (*Zingiber officinale* Roscoe). The research was carried out from October 2021 to December 2021. There were some limitations in carrying out this experiment, factors such as the short time frame (October to December) that only allowed the experiment to be carried out once in one weather condition and observation only up to two months after planting were considered. Second, the experiments were only carried out in one location, and the results obtained may differ if the experiments were carried out in different locations under different weather conditions. Third, since the initial size of the plant material (seedlings) differs little in terms of height and number of leaves, thus may affect its growth and development.

Due to time constraints, experiments were carried out for up to 10 weeks, included the first week of experimental preparation. Data collection was limited to a few parameters that exclude yield production because *Z. officinale* takes at least nine months to produce until harvest.

1.7 Significance of Study

The purpose of this study was to identify the best system for growing *Z. officinale* in soil-less media (mixture of paddy husk and coco peat). The used of Fermented Fruit Juice (FFJ) and Fermented Plant Juice (FPJ) as booster to increase the *Z. officinale* growth performance. Bench fertigation systems can assist in crop maintenance by producing increased production efficiency.

CHAPTER 2

LITERATURE REVIEW

2.1 Background of the Halia Bentong (*Zingiber officinale* Roscoe)

Figure 2.1: Halia Bentong (*Zingiber officinale* Roscoe)

Halia Bentong (*Zingiber officinale* Roscoe), a member of the Zingiberacae family, a well-known spice that used in cuisine all over the world (Kumar Gupta & Sharma, 2014) and for over 2000 years, it was thought to have been used as a spice (Bartley & Jacobs., 2000). This type of *Z. officinale* was widely grown mainly in tropical and subtropical countries where China and India were the world's major producers (Blumenthal et al., 2000). According to Sajeev et al. (2011), in 2009, India had the world's highest ginger production (0.38 million tonnes).

Z. officinale has long leaves, bright green blooms, and thick tuber rhizomes. This was a kind of storage root with a strong flavour. The component composition of *Z. officinale* was numerous and varying according to where it was grown and whether the rhizomes were fresh or dried (Ali, B.H et al., 2008). The importance of *Z. officinale* was increased recently because of its low toxicity and wide range of biological and pharmacological applications such as antitumor, antioxidant, anti-inflammatory, antiapoptotic, cytotoxic, anti-proliferative, and anti-platelet activity (Sekiwa et al. 2000; Shukla & Singh, 2007; Wei et al. 2005; Young et al. 2005).

2.1.1 Taxonomy of *Zingiber officinale* Roscoe

Domain:	Eukaryota
Kingdom:	Plantae
Phylum:	Spermatophyta
Subphylum:	Angiospermae
Class:	Monocotyledonae
Order:	Zingiberales
Family:	Zingiberaceae
Genus:	Zingiber
Species:	Zingiber officinale

2.1.2 Ecological and Nutritional Benefits of *Zingiber officinale* Roscoe

Z. officinale was grown from sea level to 1500 metres above sea level in the tropics, but it was most commonly seen at lower elevations. As a crop, *Z. officinale* was been deliberately introduced across the humid tropics (Sutarno et al., 1999). Warm, sunny and shady conditions were a condition required by *Z. officinale* especially during youth. The total range of suitable rainfall distribution is 2500-3000 mm, spread evenly throughout the year. However, *Z. officinale* was particularly suitable to be in additional irrigation conditions below 2000 mm as it is not resistant to dry places. Soils with a pH 6.0-7.0 were very suitable for the cultivation of Z. *officinale*. *Z. officinale* was very susceptible to water logging. As it is such a demanding crop, the soil fertility must be high, or manure should be used to improve soil fertility.

Z. officinale has many medicinal uses. *Z. officinale* root was used to reduce and treat some common ailments, such as headaches, colds, nausea, and emesis. Many bioactive compounds in *Z. officinale* have been identified, such as phenolic compounds and terpenes. Phenolic compounds are mainly gingerols, shogaols, and paradol, which contribute to the various bioactivity of *Z. officinale* (Stoner G,D., 2013). Fresh or dried rhizomes are very popularly used to treat various ailments, while essential oils are used topically as analgesics. Nausea and vomiting associated with surgery, vertigo, travel pain and morning sickness are among the diseases that often make *Z. officinale* as a treatment to get rid of it.

However, the safety in the use of *Z. officinale* during pregnancy can be disputed, and pregnant women should be careful before taking it and need the advice of doctors. *Z. officinale* can cause allergic reactions when applied topically. *Z. officinale* has recently been discovered to have biological activities such as antioxidant activity (Nile, S.H & Park, S.W, 2015), anti-inflammatory activity (Zhang, M et al. 2016), antimicrobial activity (Kumar, N.V, et al. 2014), and anticancer activity (Citronberg, J et al., 2013). Furthermore, studies have shown that *Z. officinale* has the potential to prevent and manage diseases such as neurodegenerative, cardiovascular disease, obesity, diabetes mellitus, nausea and vomiting caused by chemotherapy, and respiratory disorders. (Townsend, E.A et al., 2013).

2.2 Use of Fertigation in Crop Cultivation

Fertigation was an irrigation system that combines fertilization and water system by injecting a solution of fertilizer and other water solvents into the cultivation media. This method was particularly famous in horticulture and extensive agriculture. Fertigation systems have distinct advantages over other fertilization methods when used efficiently because they apply the appropriate amounts of fertilizer based on the nutrient requirements of the plant.

Beside expanding yield, fertigation can also reduce fertilizer use by providing fertilizer solutions dependent on crop formulation. There were two basic ways to deal with fertigation used in soilless medium by mixing each unit of water flowing through the irrigation system and measuring the fertilizer stock solution accurately. In open fields, this quantitative approach was used where the horticulturist must initially calculate how much fertilizer should be applied per unit area.

2.2.1 Bench fertigation system

In fertigation systems, materials such as polyethylene bags were often used by farmers. However, bench planting techniques were used in this study. The bench planting technique was an assembly of a box-shaped frame built using lightweight steel with black net insert to hold growing media and planting materials. On each planting bench, the media (mixture of paddy husk +coco peat) were placed in the net. This planting bench performs the same function like a polybag, but it provided a wider space horizontally for *Z. officinale* root to spread and also contributes to the rhizome's growth.

2.2.2 Media Used in Bench Fertigation

a. Paddy husk

Paddy husk was used as an alternate medium in the fertilization of other crops (El Sharkawi et al., 2014). Paddy husk was chosen as growing medium because of its granular composition, insoluble in water, chemically stable and high mechanical strength (Awang et al., 2009). It was a popular cultivation medium, both raw and burnt. The low production cost of this material was an advantage. According to Laiche (1989), when planting woody landscape crops grown in containers, the utilization of composted paddy husk as an organic amendment to compartment media related well with media comprising exclusively of pine bark. The use of burnt paddy husk was more important in this study. Pathogens were killed during the burning process, and it can improve aeration and drainage.

b. Coco peat

Coco peat was a natural ingredient derived from the husk of coconuts. This material acts as a moisture preserve, capable of binding large amounts of water to planting medium, and it was also good for oxygen as well as clear ventilation. Compared to other media, coco peat was easier to remove and free of pests and weeds. Modern agricultural technologies that were increasingly popular use coco peat products including fertigation system, as one of the alternatives to high value crop media. If this material was used for a long period of time, the pH value should be checked periodically. The pH value can be balanced by passing clean water through the media. Because of its low cost and easily available, most farmers used coco peat as the primary medium to cultivate *Z. officinale* (Yaseer et al., 2016).

2.2.3 Pest and Disease Management

The production of *Z. officinale* was influenced by both biotic and abiotic factors. Viruses, bacteria, fungi, and nematodes were examples of biological factors (Paret, M.L et al., 2010 & Sharma B.R et al., 2010). Bacteria were the most important biotic factors because they can cause mild wilt and rot. These plants were afflicted with bacterial diseases that caused by bacteria such as *Ralstonia solanacearum*, *Pythium* species, *Fusarium* species, *Sclerotium* species, *Pseudomonas* species, and others (Dake & Edison, 1989; Senapati & Ghose, 2005; Paret et al., 2010; Sharma et al., 2010). Cultural, biological, and chemical pathogen suppression methods were used in the treatment of these diseases. (Suseela Bhai, R et a., 2005). One of the most devastating diseases of *Z. officinale* was so-called soft rot, which caused significant yield loss wherever this crop was grown. The disease reduces the potential of *Z. officinale* yields during storage, and open shelf with many losses exceeding 50%. (Ramteke & Kamble., 2011). The diseases were primarily caused by Pythium species, but the fungus Fusarium spp. was also involved (Stirling et al., 2009).

Two diseases borne by rotten soil-rhizomes caused by *Pythium aphanidermatum* and wilted bacteria caused by *Ralstonia solanacearum* (*Pseudomonas solanacearum*) were the main constraints involved in the conservation of *Z. officinale* germ plasma (Archana et al., 2013). The fungus was a significant pathogen capable of causing rhizome disease, soft rot, *Sclerotium* rot, and jaundice. On *Z. officinale*, nematodes cause root nodule disease, mosaic and chlorotic virus causes a decrease in rhizome yield. Insects that attack *Z. officinale* include shoot borer (*Conogethes punctiferalis*), rhizome scales (*Aspidiella hartii)*, rhizome flies, and thrips. Abiotic factors on *Z.*

officinale caused sunburn (due to high light intensity) and lime-induced chlorosis (due to excessive liming in the soil). Due to the high light intensity, young of *Z. officinale* were very susceptible to sunburn when the temperature exceeds 30°C. Mild sunburn only affects the leaves, whereas severe sunburn harms the entire shoot (Kar, A.K. & Mandal, M., 1969). As a result, understanding the disease's symptoms, as well as the organism responsible and protective measures were critical.

2.2.4 Fertilizer Application in *Z. officinale* Production

Fertilizer was applied in moderate amounts at the start of planting, depending on the suitability of growth. Chemical fertilizers can be dissolved in water quickly and will easily release nutrients to plants. Fertilizer requirement was defined as the precise amount of fertilization required at various stages of development. The use of various types of cultivation media can also influence fertilizer uptake by crops. Chemical fertilizers (mixed fertilizers; NPK, single-dressing fertilizers; urea, and compound fertilizers) and organic fertilizers were commonly used in the production of *Z. officinale* (food waste source, agricultural waste, or even from animal waste). In fertigation systems, soluble chemical fertilizers (solutions A and B) were commonly used. Because AB fertilizer was insoluble, it was the most commonly used chemical fertilizer in fertigation systems. AB fertilizers were classified into two nutrient elements: macronutrients and micronutrients. This fertilizer was in the form of a liquid solution. Macronutrients required were carbon, nitrogen, hydrogen, oxygen, phosphorus, potassium, calcium, magnesium, and sulphur while micronutrients required were iron, manganese, boron, molybdenum, copper, zinc, chlorine, nickel, cobalt, silicon and sodium (Kathpalia, R., & Bhatla, S. C., 2018)

2.2.5 Benefits of Fertigation System

The fertilizer solution was evenly appropriated to the crop via drip irrigation in fertigation. As a result, the supply of nutrients to each crop was very high, resulting in higher growth performance. Through a fertigation system nutrients and water was dissolved directly to the active root area so that there was a greater absorption by the plant. The total nutrients given can be controlled in terms of the amount based on the requirements of the plant according to its growth stages. The fertigation system has the advantage of fertilizing the plants with a predetermined amount and at a predetermined time without wasting any fertilizer. Along with saving water and fertilizer, this method significantly reduces the use of time, manpower, and resources (TNAU Agritech Portal., 2016). The fertilizer applied will go directly to the root zone, for easy absorption by the plant.

2.3 Issue and Potency of *Z. officinale* Cultivation

Z. officinale was a member of the ginger family and was a common ingredient in both vegetarian and non-vegetarian dishes. *Z. officinale* was used to treat coughs and asthma in traditional Indian medicine, where it was made into fresh ginger juice with a little bit of fresh garlic juice mixed with honey. In the cultivation of *Z. officinale*, the selection of rhizomes where the green eyes of the rhizomes were used as planting material plays an important role because it gives a higher percentage of the rhizomes to grow well. In order to achieve good production results, plant material must be in good physical condition. The higher the seed size, the higher the yield (Hailemichael & Tesfaye., 2008). However, some rhizomes do not have eyes or buds. By soaking the rhizomes in warm water, it can speed up the growth of buds by stimulating the emergence of buds. By soaking the rhizomes in fungicides, potential sources of disease or pests that can be hosted in the rhizomes were typically destroyed.

Pests and diseases were common in plant cultivation, and they can attack *Z. officinale* as well as other crops. Several factors influence the attack; the planting area's environmental conditions and crop maintenance were included. The surrounding planting area must be kept clean and well-maintained. The grass demon was the most common pest that attacks the *Z. officinale* plant (*Udaspes folus*). The most common pathogenic bacteria invading *Z. officinale* were (*Ralstonia solanacearum*), leaf spot (*Phyllosticta zingiberi*) caused by a fungus, and *Fusarium oxysporum*, a root disease (Meenu & Kaushal., 2017). Rhizome plants were frequently attacked by pests and diseases like these. To control leaf spots and root diseases, fungicides were commonly used. To prevent the disease from spreading to other parts of the plant, the affected part of the leaf should be pruned. To prevent root diseases, the rhizomes chosen for planting material must be of high quality and disease-free. Bacterial invasion can be avoided by removing the infected polybag from the cultivation area and treating it appropriately (Hepperly, P et al., 2004). If treatment fails to cure the plant, it should be destroyed.

Weeding can also be done manually or with the use of herbicides. Herbicides were recommended for large-scale agriculture to reduce weed problems. Pesticides were only used when they were absolutely necessary. Furthermore, the affected area must be relocated away from the planting area. To avoid drought, the *Z. officinale* requires a constant supply of water. Excessive watering, on the other hand, should be avoided to prevent the growth of fungus on the roots. The best time to water was early in the morning. During the rainy season, watering activity can be reduced because the plants have enough water for growth.

2.4 Fermented Fruit Juice (FFJ)

Fermented Fruit Juice (FFJ) was a nutritional activating enzyme that works well in natural agriculture (Thwe, A.A., 2017). FFJ was similar to FPJ in their production and their main ingredients are fruits and leafy vegetables. FFJ was a stimulant that was used to revitalise crops, livestock, and humans. Banana, papaya, mango, grape, watermelon, apple, and other common fruits can be used as main ingredients. Among recommended fruits, sweet taste (Min, L.L & Thwe, A.A, 2017), fruits such as banana, papaya, and pumpkin were used in this study to make this FFJ.

Furthermore, FFJ was often used in enhancing yield reproduction in certain green vegetables. An application such as sprays on leaves and also indirectly to the soil can be used where it feeds the microbiome and improves soil health. The low manufacturing cost of FFJ and very easy to prepare was one of its advantages. It can be made from a variety of non-citrus fruits, including vegetables high in potassium. Sugar/molasses was used as a fermentation agent in FFJ, and the process takes seven to ten days before it can be used.

The fermentation process was generated by sugar/molasses, which extracts nutrients and enzymes from the fruit and converts them into a liquid extract that can be kept refrigerated for a year or more. With only a low manufacturing cost, it can be made yourself at any time. Seasons such as the arrival of a new season when fruiting plants need it, or for regular soil applications for leafy vegetables and general soil health are strongly encouraged. The use of FFJ as a leaf fertilizer in conjunction with a fertigation system was expected to boost and improve plant yields, including *Z. officinale* quality.

Because the form of nutrient application was preferable to direct fertilizations, leaf application becomes available to crops immediately (Naz et al., 2011). FFJ can be used to improve plant fertilizations and increase yield (Min, L.L & Thwe, A.A., 2017). It can be applied directly to the soil as a leaf spray or indirectly to the soil, where it feeds the microbiome and improves soil health (Reichenberg & Pritts., 1998).

Figure 2.2: Ingredients used in making of FFJ (banana, pumpkin, papaya, and molasses)

2.4.1 Benefits of Using FFJ as Booster

FFJ has a variety of applications, the majority of which was beneficial to agriculture. It has a variety of applications, one of which was as a flower inducer and fruit settler. Most organic farmers have proven that FFJs made from readily available fruits such as over ripe bananas, papayas and pumpkins are effective when sprayed on the leaves at a rate of 2-4 tablespoons/ gallon of water from early flowering to fruiting. These fruits were high in phosphorus and potassium, both of which were required during the flowering and fruit set stages (Allan, P., Taylor, N. J., & Dicks, H. M, 1998). Furthermore, FFJ was effective at increasing the activity of soil microorganisms. This has the potential to directly increase the yield of tuber crops such as ginger FFJ was applied to the ground at a rate of 1 teaspoon per litre of water. The carbohydrate and sugar content of FFJ serves as an energy source for soil microorganisms, allowing them to function more quickly. Increased microbial activity increases nutrient availability for plant absorption. Organic farming and the use of organic soil amendments were critical for the long-term functioning of ecosystems (M Naiji et al., 2018). A fermented juice is a type of organic soil amendment that can improve and maintain soil health and quality.

2.5 Fermented Plant Juice (FPJ)

Fermented Plant Juice (FPJ) was now widely used in seed and soil treatment solutions, as well as plant nutrition. It was made of vegetables that have withered and not fresh such as spinach, water spinach and mustard leaf that were allowed to ferment for about 7 days with the help of brown sugar/molasses. Brown sugar/molasses extracts juice from plant material through osmosis and also serves as a food source for microbes involved in fermentation. It is safe to eat and non-toxic. The selection of suitable plants to make FPJ was critical for its success, as the use of growing plant species tips, such as fast growers. Flowers, flower buds, and immature fruits can also be used.

Hard or woody parts of the plant were less desirable because they produce little plant juice. However, due to the effect of this process on plant chemistry, plant parts should be harvested while the plant was in respiration mode which before sunrise, rather than photosynthesis mode (during the day). Collecting plant parts during or after rain should be avoided to preserve surface microbial populations (lactic acid and yeast producing bacteria) that will carry out the fermentation process and the collected plant parts should not be rinsed. Because of the low microbial levels, improper fermentation and/or low plant juice yields will occur.

Figure 2.3: Ingredients used in making of FPJ (mustard leaf, water spinach, spinach, and molasses)

2.5.1 Benefits of Using FPJ as Booster

Agricultural production also makes use of FPJ. It has a variety of applications, including seed treatment before sowing, where the seeds should be soaked in a 0.2% solution for 4-5 hours to support germination, and as a starting solution to germinate seeds. Furthermore, FPJ was used as a natural tree growth enhancer, where from the seedling stage to the pre-flowering stage, 1 teaspoon of FPJ per litre of water was mixed and sprayed on the leaves or applied directly to the soil around the plant. It can also be used on a weekly basis, depending on the plant's strength. FPJ was an excellent source of energy for microbial activity in the soil. FPJ can be applied to the soil as an energy source to boost the activity of soil microorganisms. Plants will benefit from this activity because nutrients will be made available to them. However, it should be noted that there was no overdose with the use of FPJ. It can be used on its own. However, water the soil first before applying FPJ to avoid scorching the roots.

CHAPTER 3

MATERIALS AND METHODS

3.1 Locations of the Study

This study was conducted at the nursery of University Malaysia Kelantan, Jeli Campus (5.6990˚N, 101.8464˚E) in Kelantan, Malaysia from September to December 2021. This nursery area was specially prepared for students to do their research projects and it was suitable as a nursery for the cultivation of *Z. officinale*.

3.2 Materials

The planting materials were used for this study; 3 months old seedling of *Z. officinale*. In this study, twenty four seedling of *Z. officinale* were used. The mixture of paddy husk (raw; 30% and burnt; 30%), with coco peat (40%) were used as cultivation media in this study. Fertilizers used were solution A and solution B which contain macro and micronutrients. Material for the bench fertigation systems were black net, pump, PVC pipe, tank and lightweight steel for the frame structure. Different materials or instruments were utilized; a watering can, pressure sprayer, and scoop. The watering can and pressure sprayer were required as reinforcement. The scoop and tray were utilized during the arrangement of the media. The fertigation set including tools like water tank, water pump, EC meter and PVC pipe. EC meter was used to decide the perfect amount of the nutrient added into the water prior to watering the *Z. officinale*. Suitable EC of the fertigation solution was between 1.8µ and 2.3µ (Yaseer et al., 2019). In this study, Fermented Fruit Juice (FFJ) and Fermented Plant Juice (FPJ) as boosters were used. The FFJ was from a mixture of over ripe fruits such as 1kg banana, 1kg papaya, and 1kg pumpkin while the FPJ was from vegetables that have withered and not fresh which are 1kg spinach, 1kg water spinach and 1kg mustard were used as a treatment. The fruits and the vegetables were mix together with 3kg of molasses

3.3 Research Methodology

3.3.1 Preparation of the *Z. officinale* Seedlings

The seedlings of *Z. officinale* were sourced from the tissue culture nursery. The 3 months old seedlings chosen were free from diseases and pests. The seedlings of *Z. officinale* were planted in nursery using bench fertigation. Twenty four seedlings of *Z. officinale* were studied and divided into two groups; the first twelve samples were used as control while another twelve samples were treated with FFJ and FPJ as booster. The seedling beds were filled with media and the seedlings were spaced about 1 inch apart.

Figure 3.1: Seedlings of *Z. officinale*

Figure 3.2: *Z. officinale* in bench fertigation

3.3.2 Media Preparation and Experimental Design

The mixture of coco peat and paddy husk (raw and burnt) which ratio 2:1:1 were used in these studies. Similar fertilizers were applied for all treatments media consists 24 seedlings of *Z. officinale*. 24 samples were tested which are 12 samples as control and 12 as treatment with FFJ and FPJ booster. Only one bench was used in this study that consist one treatment (12 samples) and one control (12 samples). The bench was equipped with a drip irrigation system that supply water from a tank fitted with a water pump. This fertigation system was placed on a high bench so that data can be recorded easily and also the run-off can flow directly under the bench. The arrangement for sample control and treatment were mixed and not arranged equally in rows.

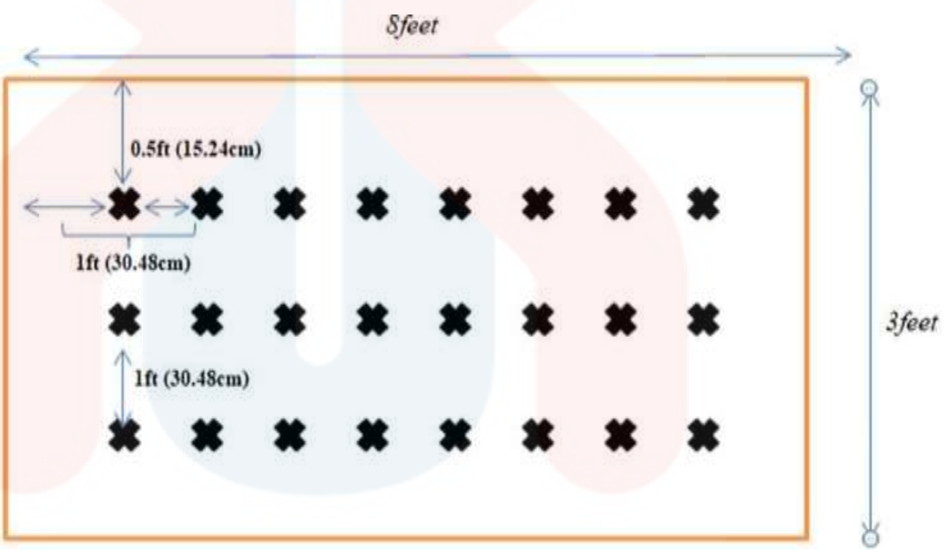

Figure 3.3: Design of planting area for treated sample and control

3.3.3 Fertilizer Application and Maintenance

The bench fertigation system was set up as a rectangular shape box on top of a concrete bench with a height of 1m. The side wall of the box was made by lightweight steel. The rectangular frame structure is 3 feet by 8 feet. Black nets were used to line the frame around to hold the media. The fertilizer used in this study was formulated by MARDI based on the prerequisites and requirements of rhizome crops (Yaseer et al., 2009). The components of the fertilizer utilized were all water-soluble.

The stock solutions for A and B, the macro and micro nutrients were prepared separately. Solution A contained calcium nitrate and iron, whereas Solution B contained all of the various components. All components were added individually to guarantee that they totally dissolved in the water. In the preparation of solution A, the macro nutrient were added to a container containing tap water at pH (5.5 - 6.5) and mixed until dissolved before being poured into a 100-litre vessel. Iron powder was applied to another compartment containing tap water, stirred until fully dissolved and afterward added to the vessel. The similar method was utilized to prepare the solution B. The irrigation solutions were prepared in a 1.500 litre tank. Stock A and stock B were added to the tank in a 1:1 ratio until the required electrical conductivity (EC) accomplished. The EC of the fertigation solution ranged between 1.8 µS and 2.3 µS. A digital timer was utilized to enforce irrigation scheduled at three times per day.

3.3.4 Preparations of FPJ and FFJ

The fermentation process of FPJ and FFJ were almost the same where both boosters use molasses as the main ingredient in the mixture. However, what differentiates it was in terms of its main ingredients where FFJ was prepared using over ripe fruits such as bananas, papayas, pumpkins and others while FPJ was prepared using vegetables that have withered and not fresh from water spinach, mustard leaf and spinach. The main reason for using withered and overripe fruits and vegetables is to reduce agricultural waste, as such fruits and vegetables cannot be sold or eaten and will continue to be discarded. There are plant boosters (FFJ and FPJ) that use agricultural waste materials to keep it from being discarded when it were damaged. For FFJ, the fruit should be peeled and cut into small cubes before being placed in a large black container while for FPJ whereas the vegetables are finely chopped approximately 1 inch. Small cuts will speed up the decomposition process taking place.

In this study, for FFJ 3kg of fruit was used; 1kg of banana, 1kg of papaya and 1kg of pumpkin. For FPJ, 3kg of vegetables were used; 1kg of water spinach, 1kg of spinach and 1kg of mustard leaf. Add the same weight of molasses as the weight of fruit/vegetables that were 3kg of molasses have been used. Mix fruits/vegetables with molasses together so that all were completely coated with molasses. Once finished mixing, cover the black container with a cloth and tie with string. The mixture must be breathable, but should be monitored to avoid pests. Keep the container in a cool, shady location away from direct sunlight.

The fermentation process was completed within seven days. The mixture was mixed every 2 days. After 7 days, strain the mixture and pour the liquid into containers, leaving about one-third of the air in each container. The bottle cap should be loose for the next two weeks. This was because it allows the gas produced during the fermentation process to be removed. After two weeks, tighten the bottle cap and refrigerate. This will stop the fermentation process and the FFJ/FPJ was ready for use. To spray on leaves and soil, mix two teaspoons of juice in one gallon of water.

3.4 Data Collection and Analysis

The data were collected on a weekly basis on every Monday. The impacts of media utilized on growth of *Z. officinale* were evaluated by observing the height of the plants, number of leaves, number of tillers and the relative weight of the whole plant. All collected data were analysed using one-way ANOVA analysis in SPSS software. Means were separated using Tukey test HSD as the test of significance at $p \leq 0.005$. the results demonstrated the significance and appropriateness of the variance and mean of the data to determine the best treatment for *Z. officinale* development using a bench fertigation system.

3.5 Growth Parameter

3.5.1 Plant Height

The plant's height was measured from the base to the tip of the shoots and recorded in each week. Measuring tape was used to make the measurement easier.

Figure 3.4: Measuring tape was used to measure the seedlings of *Z. officinale*

3.5.2 Number of Leaves

The number of leaves were counted and recorded in each week.

3.5.3 Number of Tiller

The number of tillers were counted and recorded in each week.

3.5.4 Relative Weight of the Whole Plant

The final weights of the 24 samples of *Z. officinale* were weighted using electric weighing and data was recorded at the end of the experiment.

Table 3.1 Summary of replication of treatment

TREATMENT	MEDIA	REPLICATION
Control (AB fertilizer)	Cocopeat + paddy husk (raw & burnt)	12
Treatment (FPJ & FFJ)	Cocopeat + paddy husk (raw & burnt)	12
Total number of samples		24

3.6 Research Flow Chart

Preparation of bench fertigation system at nursery in UMK Campus, Jeli, Kelantan

Planting material included FPJ and FFJ were prepared.

24 seedlings of *Z. officinale* were planted and were divided into two category; 12 seedlings as treatment and 12 seedlings as control.

Preparation of fertilizer for fertigation process (drip irrigation)

Data were recorded continuously every week on Monday.

Data were analysed by using Statistical Package for Social Science (SPSS), and subjected to one-way ANOVA (The Turkey test HSD).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Growth Performance of *Zingiber officinale* Roscoe

Z. officinale or commonly known as Halia Bentong was chosen and used in this study. This variety matures in 8 to 10 months and can be harvested as young ginger in 3 to 6 months. The 3 months of *Z. officinale* seedlings were used in this study. This sapling has a young, undeveloped rhizome. Despite the presence of young rhizomes, new growth rates were observed 7 days after transplantation to the fertigation bench. *Z. officinale* was typically propagated vegetative by rhizomes, with shoots appearing one to two weeks after sowing. A small portion of the rhizome known as the seed rhizome was used to propagate *Z. officinale* (Dupriez & De Leener, 1992; Borget, 1993; Ravindran et al., 2004). Rhizome size and cultivation method, according to Aiyadurai (1996), were two important aspects in *Z. officinale* production. Rhizome size was an important factor in obtaining a high yield, as it is the plant material that affects both the grower's economic return and the crop's establishment (Girma & Kindie., 2008).

The *Z. officinale* studied was grown in only one type of medium, which is in a mixture of paddy husk and coco peat where according to Ortega et al. (1996) this types of media is a cheaper soil-alternative substrate and available locally. Furthermore, according to Yaseer et al. (2015) the used of 100% coco peat will provide ventilation and promoting the rapid growth of *Z. officinale*. However, in this study, mixture of coco peat and paddy husk (burnt and raw) was used as the cultivation medium, whereas Yaseer et al. (2015) used burnt paddy husk. As a result, the type of media used can affect air capacity, which in turn affects the growth performance of *Z. officinale* in the fertigation method.

Next, according to Table 4.1, the survival rate of *Z. officinale* plants that were only given AB fertilizer (**C**) was 58.3%, with 5 dead plants out of 12 plants. Meanwhile, the highest survival rate of *Z. officinale* was observed in the treatment of FPJ (**T1**) and FFJ (**T2**), which was 83% with only 2 dead plants out of 12 plants. The parameter that were observed in this study are plant height, number of leaves, number of tillers, and the relative weight of the whole plant of *Z. officinale*.

Table 4.1: Survival rate of *Z. officinale*

SAMPLE	TOTAL NO OF PLANTLETS	SURVIVAL RATES (%)
CONTROL (AB FERTILIZER)	12	58.3
TREATMENT (FPJ & FFJ)	12	83.0

4.1.1 Plant Height

From week 1 to week 8, the plant height (in cm) of *Z. officinale* supplied with AB fertilizer as control (**C**), **T1** as FPJ, and **T2** as FFJ was measured. The FPJ (**T1**) was supplied from week 1 to week 4, while FFJ (**T2**) was supplied from week 5 to week 8. The 24 samples of *Z. officinale* were planted in the same media, which was a mixture of paddy husk and coco peat, and using bench fertigation by complete randomise design (CRD).

Figure 4.1 shows the graph of plant height which compared between **C** and **T1** from the week 1 to week 4. The highest plant was recorded in **C,** during the first and third weeks, which were 20.5 ± 2.12 (cm) and 28.29 ± 6.42 (cm) respectively. Meanwhile for **T1**, the highest reading of plant height was recorded; in the second and fourth weeks, which were 24.78 ± 5.56 (cm) and 28.33 ± 7.03 (cm) respectively. The mean value of **T1** is higher than mean value of **C** (except week 1) (Appendix B1) for the first of 4 weeks.

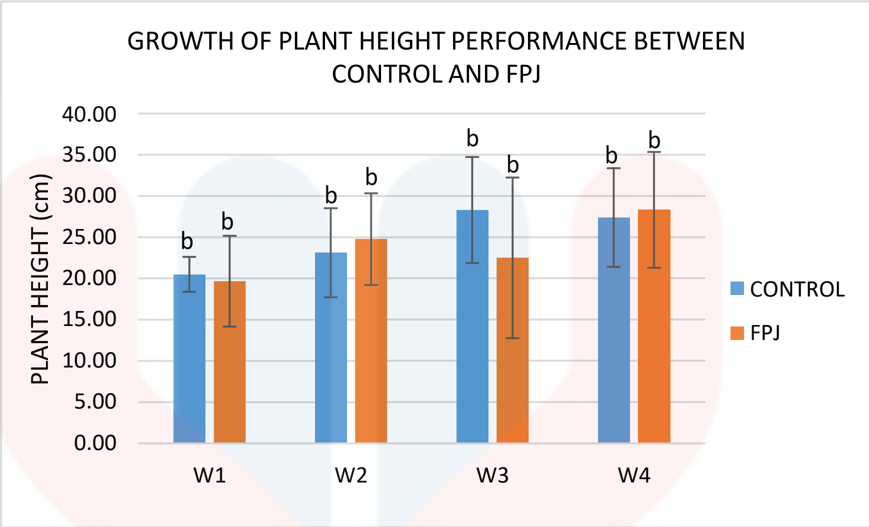

Figure 4.1: Comparison of plant heights between control and FPJ from first week until the fourth week 4.

*C= AB FERTILIZER, T1= FPJ, T2=FFJ

Figure 4.2 also depicts the growth performance of the plant height between AB fertilizer (**C**) and FFJ (**T2**) from week 5 to week 8. The highest plant was recorded in **T2** from week 5 to week 8, with values of 28.71 ± 7.14 (cm) (week 5), 29.27 ± 7.34 (cm) (week 6), 22 ± 13.93 (cm) (week 7), and 20.29 ± 16.58 (cm) (week 8). Thus, the use of **T2** clearly enhances the growth performance of *Z. officinale* than AB fertilizer (**C**). Overall, week 6 recorded the highest record which is 29.27 ± 7.34 (cm) for the record of plant height from week 5 until week 8 between **T2** and **C**, indicated that the use of **T2** as booster was more effective on *Z. officinale* growth rate.

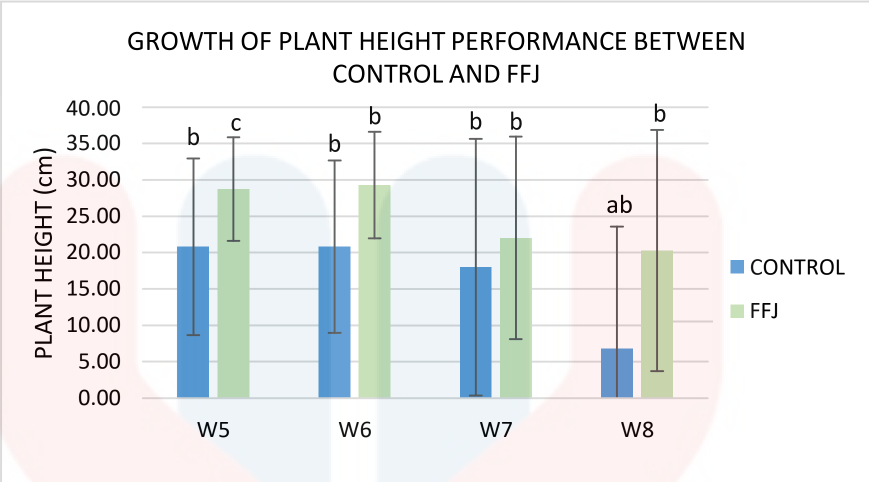

Figure 4.2: Comparison of plant heights between control and FFJ from first week 5 until week 8

*C= AB FERTILIZER, T1= FPJ, T2=FFJ

4.1.2 Number of Leaves

Figure 4.3 shows the number of leaves between the plants treated with AB fertilizer (C) and FPJ (T1) from week 1 to week 4. More number of leaves was observed for the T1 compared to the number of leaves by using C. From week 1 to week 4, T1 recorded 6 ± 1.86, 6.58 ± 2.20, 6 ± 2.80 and 6.67 ± 2.31, while C recorded 5.42 ± 1.73, 5.42 ± 2.84, 5.08 ± 2.15 and 5.58 ± 2.15. This shows that the results were more encouraging when T1 was used as booster on *Z. officinale*.

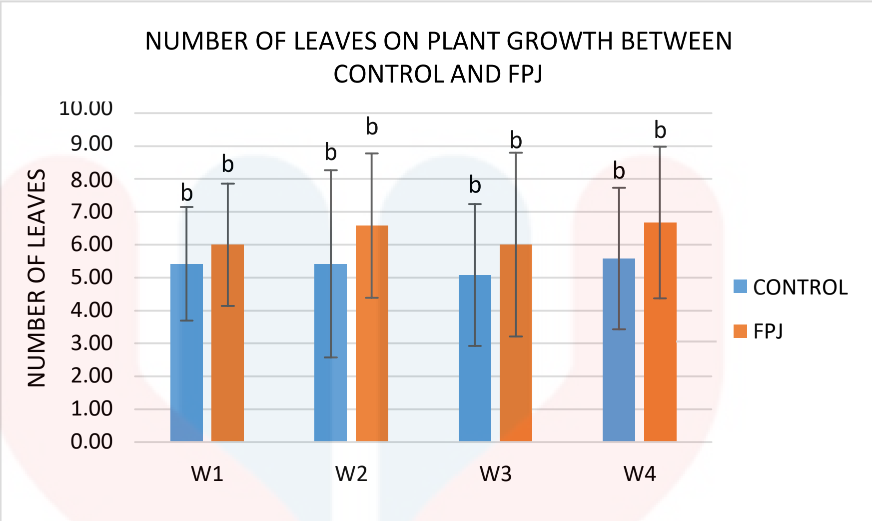

Figure 4.3: The number of leaves counted between control and T1 from week 1 until week 4

*C= AB FERTILIZER, T1= FPJ, T2=FFJ

Figure 4.4 shows the number of leaves observed between *Z. officinale* treated with AB fertilizer (**C**) and FFJ (**T2**) from week 5 until week 8. Over the course 4 weeks, this clearly shows the average number of leaves increasing continuously throughout the week. Adaptation to the use of **T2** was well received where the production of the number of leaves increased during this 4 week period compared to using **C**. From week 5 to week 8, **T2** recorded 6.42 ± 2.35, 6.5 ± 2.65, 4.08 ± 2.71 and 2.83 ± 2.13, while **C** recorded 4.50 ± 2.88, 4.08 ± 3.0, 3.58 ± 3.23 and 2.83 ± 3.13.

However, the leaves of *Z. officinale* also suffered wilted as in Figure 4.5. When *Z. officinale* was still in its early stages of cultivation, leaf development may continue to change rapidly. According to their natural growth period, the number of leaves may decrease when reaching the peak of the planting period until the end of the planting period because the old leaves will fall off and be replaced with new leaves. Previous studies also revealed the number of leaves will increase as the age of *Z. officinale* increased (Melati et al., 2016).

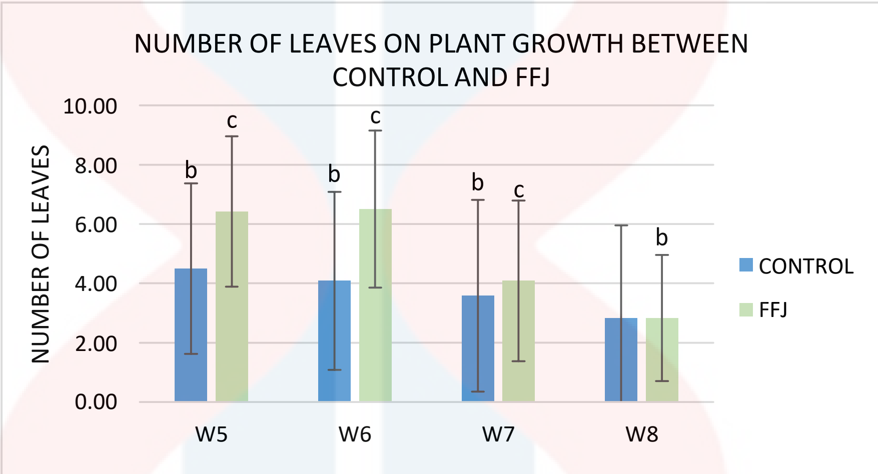

Figure 4.4: The comparison of the number of leaves between control and FFJ from week 5 until week 8

*C= AB FERTILIZER, T1= FPJ, T2=FFJ

Figure 4.5: Wilted leaves of *Z. officinale*

Z. officinale was not immune to wilted leaves caused by ginger bacterial wilt disease, in which the green leaves turn yellow and curl as a result of water pressure caused by bacteria that block the flow of water on the *Z. officinale*'s stem, the leaves begin to turn yellow, and necrosis occurs (Nelson, 2013; White et al., 2013). In the study, it was clear (Figure 4.4) that the number of leaves for control (**C**) and treatment (**T2**) decreased from week 6 to week 8. The first signs of bacterial wilt in ginger were when the lower leaves extend upwards until all of the leaves appear golden yellow (Figure 4.5), and it is also said to move upwards through the vascular system and eventually block water transport, causing wilt (Tahat M.M & Sijam K., 2010).

Previous research from Lemessa, F & Zeller, W. (2007) contends that there was no single effective control measure against this pathogen. As a result, ginger bacterial wilt disease persists, and farmers who grow *Z. officinale* consider it a major production constraint. As a result, some bacterial wilting control was recommended through the use of a combination of various methods such as host resistance, cultural practises, biological and chemical control in integrated disease management schemes (Bekele, K & Berga, L., 1998)

4.1.3 Number of Tillers

According to the graph in Figure 4.6, there was no significant difference in the number of tillers between *Z. officinale* treated with AB fertilizer (C) and FPJ (T1) in the first 4 weeks. The number of tillers for T1 was 1.25 ± 0.45

(week 1), but with no change from week 2 to week 4 (1.33 ± 0.49). Figure 4.6 depicts this as well when C recorded the same amount as T1 in week 1 and decrease in the number of tillers of 1.17 ± 0.39 (weeks 2 and week 3) and 1.08 ± 0.29 was recorded in week 4, where the number of tillers decreased from week 1 to week 3. When *Z. officinale* only used AB fertilizer (C), this showed a significant decreased when compared to *Z. officinale* that used T1 as booster. Although the T1 as treatment had the most tillers in the first 4 weeks, there was a significant difference between this treatment and the control p ≤ 0.05 (Appendix C3).

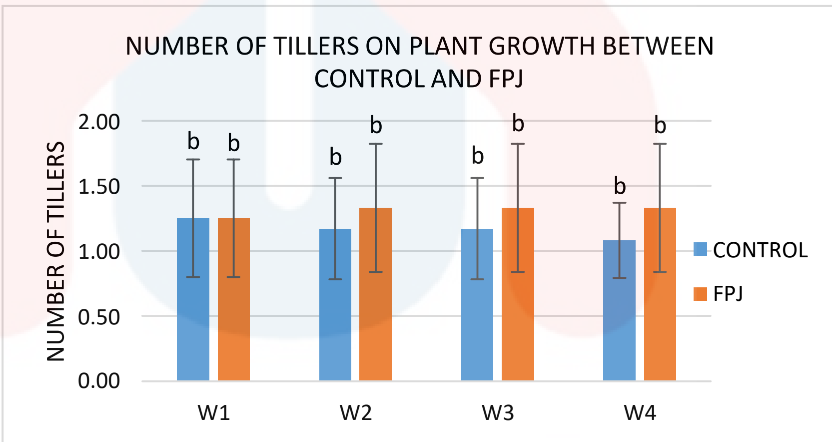

Figure 4.6: The comparison between the number of tillers control and FPJ from week 1 until week 4

*C= AB FERTILIZER, T1= FPJ, T2=FFJ

Next, based on Figure 4.7, the number of tillers on the growth *Z. officinale* between supplied with AB fertilizer (**C**) or FFJ (**T2**) are recorded from week 5 to week 8. Tillers are counted and recorded for each sapling. **T2** produced more tillers than **C**. It increased from 1.33 ± 0.49 (week 4) to 1.42 ±

0.79 and 0.92 ± 0.52 (week 5) and 1.58 ± 0.67 (week 6). However, it began to decrease in week 7 and week 8, when it was 1.42 ± 0.79 and 0.92 ± 0.52, respectively. In the last 4 weeks, the number of tillers for **C** has decreased, which recorded at 0.92 ± 0.49, 1 ± 0.60, 0.83 ± 0.58 and 0.67 ± 0.65. However, there was a significant difference in the number of tillers between the treatment and control groups at p ≤0.05 (Appendix C3). In terms of total number of tillers, **T2** had the highest record in week 6 (1.58 ± 0.67) compared to **C** (1 ± 0.60) in the same week.

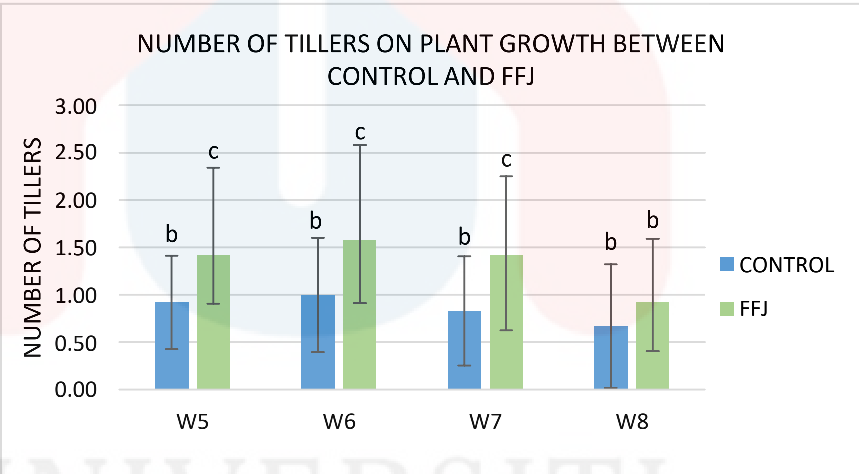

Figure 4.7: Graph number of tillers on plant growth between control and FFJ from week 5 until week 8

*C= AB FERTILIZER, T1= FPJ, T2=FFJ

4.1.4 Average Whole Plant Weight

For commercial purposes, rhizomes of *Z. officinale* were typically harvested between 7-9 months after sowing (Wilson & Ovid., 1993). However, because the crop was still in the early planting stage (5 months old), the whole of *Z. officinale* was weighted as a whole plant, rather than the rhizome yield. All of the *Z. officinale* have young rhizomes but are still small, as shown in Figure 4.8. After 8 weeks, there was no significant difference in the weight of the whole *Z. officinale* plants between control and treatment. The highest average for overall plant weight was obtained by *Z. officinale*, which when FPJ (T1) and FFJ (T2) were used as booster in this study, which is 2.17 ± 2.67 (g), and the lowest was obtained which was only given AB fertilizer (C) as a control, which is 1.8 ± 3.0 (g).

This demonstrates that growing *Z. officinale* and supplementing it with organic boosters such as T1 and T2 can increase the overall weight of the plants. According to Table 4.2, *Z. officinale* had the highest survival rate after receiving additional boosters from T1 and T2. Rhizome growth was similar because it is only in the early stages of cultivation. Rhizome exponential growth was not expected to begin until 5 months after planting.

This study, which uses organic fertilizer on plants, was similar to the study by Joshi et al. (2014), who found that vermin-compost was an organic fertilizer that can improve plant growth and yield. Similarly, organic fertilizer such as FFJ and FPJ were both environmental-friendly and cost-effective. Furthermore, according to Joshi et al. (2014), organic fertilizer was an excellent soil modifier and bio-control agent, making it more environmental-friendly than chemical fertilizer. Furthermore, previous research indicates that FFJ promotes flowering and fruiting by providing a good source of potassium, which speeds up plant absorption and produces sweeter fruits. Furthermore, it also claimed that FFJ can improve soil fertility and promote the growth of beneficial microorganism colonies (Agricultural Training Center., 2006).

Table 4.2: The average weight of the whole *Z. officinale* plants after 8 weeks between control and treatment

Sample	Weight (g)
C	1.8 ± 3.0
T1 & T2	2.17 ± 2.67

*C= AB fertilizer (control), T1= FPJ, T2= FFJ

Figure 4.8: Young rhizome of *Z. officinale*

4.2 Comparison of Plant Growth Performance between Using FPJ/FFJ and Without Using FPJ/FFJ

According to the data obtained, there were significant differences in plant height, number of leaves, and number of tillers (Table 4.3). All saplings of *Z. officinale* were grown on a bench fertigation system with soilless media consist of paddy husk and coco peat. The plant height for *Z. officinale* that received FPJ (**T1**) and FFJ (**T2**) treatment were 24.44 ± 4.08 (cm) compared to *Z. officinale* that received only AB fertilizer (**C**) (20.82 ± 5.64). The number of leaves also shows *Z. officinale* that was given **T1** and **T2** has more leaves (5.64 ± 0.32), compared to *Z. officinale* that was only given **C** (4.56 ± 0.55). Next, for the number of tillers, *Z. officinale* supplied with **T1** and **T2**, was 1.32 ± 0.12, which was higher than **C** (1.01 ± 0.12).

The graph in Figure 4.9 shows the parameters between control and treatment on *Z. officinale's* growth performance. According to the results, based on the graph in Figure 4.9, *Z. officinale* that received additional natural booster from **T1** and **T2** performed better than *Z. officinale* that received only AB fertilizer (**C**). This proves that plants receiving additional natural boosters from FPJ (**T1**) and FFJ (**T2**) have increased growth compared to untreated. However, other factors such as the initial size of the planting material used in the study must also be considered. The limited number of plant material used in this case can also affect yield because the initial size of the plant material used was not uniform, causing variations in its strength and performance.

Table 4.3: The growth performance between treatment and control

Parameter	Sample	
	Treatment (T1 & T2)	**Control (AB fertilizer)**
Height	24.44 ± 4.08	20.82 ± 5.64
Leaves	5.64 ± 0.32	4.56 ± 0.55
Tiller	1.32 ± 0.12	1.01 ± 0.12

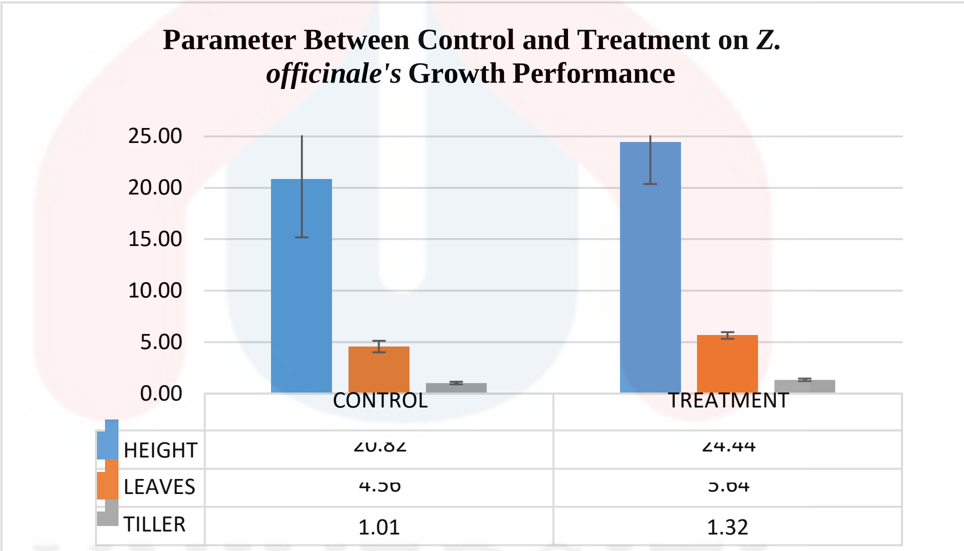

Figure 4.9: Parameter between control and treatment on *Z. officinale's* growth performance

However, overall (Figures 4.2, Figure 4.4, and Figure 4.7), it can be seen that *Z. officinale's* growth performance in terms of plant height, number of tillers, and number of leaves decreased from week 6 to week 8. This was due to a variety of factors that may be causing *Z. officinale's* growth performance to decrease. One of the possible causes would be that the December monsoon season resulted in an excess of water in the media. This excess water may have resulted in declining of *Z. officinale*.

A similar study on tomatoes and cucumbers, conducted by Mahamud & Manisah (2007); Peyvast et al. (2010), revealed that high water holding capacity reduced growth and yield for these two plants. Furthermore, soil aeration, along with water and nutrient content, was one of the most important factors influencing plant fertility (Glinski & Stepniewski, 2018; Hillel, 1998). This suggests that when the plant media becomes too wet, it can cause logging and hypoxia, which can harm most plant species, particularly those with a rooting system and produce rhizomes, such as *Z. officinale* (Humara et al., 2002). According to Beardsell et al. (1979), adequate water capacity was important because one of the most important factors for plant growth and development was an adequate amount of water in the growing substrate.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The goal of this research was to find out the effectiveness of using organic fertilizers (FPJ and FFJ) as additional boosters on the growth of Halia Bentong (*Zingiber officinale* Roscoe) when compared to just using AB fertilizer. In addition by using only soilless media (a mixture of paddy husk and coco peat) on the bench fertigation method, the effectiveness of using FPJ and FFJ was investigated. The study was conducted for 8 weeks. The findings indicated that each of the **T1** (FPJ) and **T2** (FFJ) as treatments has distinct advantages. The results showed that the highest survival rates of *Z. officinale* (Table 4.1) were achieved by using treatments from **T1** and **T2**, which was 83% with only two samples dying out of a total of twelve samples, while the control was AB fertilizer, which conferred 58.3% survival rates with five samples dying out of a total of twelve samples. The whole weight of the *Z. officinale* plants after 8 weeks (Table 4.2) showed that the **T1** and **T2** treatments had the highest result of 2.17 ± 2.67 (g) compared to the control of 1.8 ± 3.0 (g).

Plant height, number of leaves, and number of tillers were the parameters investigated. The parameters studied were divided into two sets of data, with the first 4 weeks comparing FPJ (**T1**) as treatment with AB fertilizer (**C**) as control and the last 4 weeks comparing FFJ (**T2**) as treatment with AB fertilizer (**C**) as control. The first 4 weeks (weeks 1 to weeks 4) for **T1** showed the highest performance in terms of plant height (28.33 ± 7.03;cm) (Figure 4.1), number of leaves (6.67 ± 2.31; Figure 4.3), and number of tillers (1.33 ± 0.49; Figure 4.6), while the subsequent 4 weeks (weeks 5 to weeks 8) for **T2** showed the highest performance in terms of plant height (29.27 ± 7.34;cm) (Figure 4.2), number of leaves (6.5 ± 2.65; Figure 4.4), and number of tiller (1.58 ± 0.67; Figure 4.5). The increase in plant height, number of leaves, and number of tillers demonstrated that the cultivation of *Z. officinale* with additional boosters from organic fertilizers (FPJ and FFJ) was successful in improving its growth performance.

5.2 Recommendations

In the future, more evidence on the success of *Z. officinale* cultivation using FPJ and FFJ as additional boosters, as well as bench fertigation, can be presented. Time constraints, unsuitable weather, and a limited supply of plant material were the constraints encountered in this study. Furthermore, the use of non-uniform samples may be one of the factors influencing its growth. As a result, it must be improved for future cultivation in order to gain a better knowledge of the factors influencing the growth of *Z. officinale*. The materials used in the making of FPJ and FFJ can also be changed to see how they perform in future studies. Other parameters, such as pH reading and moisture content intake for each sample, can be considered in future research to better determine the growth and performance of *Z. officinale* yield. Furthermore, for *Z. officinale* grown up to the mature rhizome harvesting stage, a longer time was required to identify the best treatment in producing better and higher quality of *Z. officinale*.

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APPENDIX A

Figure A.1: Bench Fertigation

Figure A.2: Ingredients in making FFJ

Figure A.3: Ingredients in making FPJ

Figure A.4: 3 months seedlings of *Z. officinale*

Figure A.5: Preparation of media (mixture of paddy husk and coco peat)

Figure A.6: Mix molasses with ingredients of FPJ

Figure A.7: FPJ and FFJ ready to use

Figure A.8: Spray FPJ to *Z. officinale*

Figure A.9: Sampling of *Z. officinale* in bench fertigation

APPENDIX B

Table B1: Mean and Standard Error for Plant Height

Descriptives									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
W1_HEIGHT	C	12	26.2500	5.10962	1.47502	23.0035	29.4965	19.00	35.60
	T1	12	26.0833	5.03945	1.45476	22.8814	29.2852	16.00	32.50
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	17.4444	13.14129	2.19021	12.9981	21.8908	0.00	35.60
W2_HEIGHT	C	12	22.9750	6.72027	1.93998	18.7051	27.2449	14.50	35.70
	T1	12	26.4583	5.77793	1.66794	22.7872	30.1295	16.00	34.50
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	16.4778	12.89975	2.14996	12.1131	20.8424	0.00	35.70
W3_HEIGHT	C	12	26.3750	6.07201	1.75284	22.5170	30.2330	17.50	36.00
	T1	12	28.0417	7.20107	2.07877	23.4663	32.6170	16.00	37.00
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	18.1389	14.05600	2.34267	13.3830	22.8948	0.00	37.00
W4_HEIGHT	C	12	27.4167	5.46407	1.57734	23.9450	30.8884	18.00	35.00
	T1	12	29.8417	6.57813	1.89894	25.6621	34.0212	17.00	38.50
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	19.0861	14.53736	2.42289	14.1674	24.0048	0.00	38.50
W5_HEIGHT	C	12	21.3333	11.05838	3.19228	14.3072	28.3595	0.00	34.00
	T1	12	6.0000	1.85864	0.53654	4.8191	7.1809	3.00	9.00
	T2	12	29.0583	7.03142	2.02980	24.5908	33.5259	18.00	39.00
	Total	36	18.7972	12.22750	2.03792	14.6600	22.9344	0.00	39.00
W6_HEIGHT	C	12	21.6250	11.65240	3.36376	14.2214	29.0286	0.00	34.00
	T1	12	6.5833	2.19331	0.63315	5.1898	7.9769	4.00	11.00
	T2	12	29.2083	6.99824	2.02022	24.7619	33.6548	15.00	38.00
	Total	36	19.1389	12.26820	2.04470	14.9879	23.2899	0.00	38.00
W7_HEIGHT	C	12	19.7417	14.89695	4.30038	10.2766	29.2067	0.00	41.00
	T1	12	6.0000	2.79610	0.80716	4.2234	7.7766	2.00	10.00
	T2	12	25.2417	12.65173	3.65224	17.2031	33.2802	0.00	41.00
	Total	36	16.9944	13.77901	2.29650	12.3323	21.6566	0.00	41.00
W8_HEIGHT	C	12	13.9917	15.70237	4.53288	4.0149	23.9685	0.00	41.00
	T1	12	6.6667	2.30940	0.66667	5.1993	8.1340	3.00	10.00
	T2	12	23.1167	15.06482	4.34884	13.5449	32.6884	0.00	42.50
	Total	36	14.5917	14.03812	2.33969	9.8419	19.3415	0.00	42.50

Table B2: Mean and Standard Error for Number of Leaves

Descriptives									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
W1_LEAVES	C	12	5.4167	1.72986	0.49937	4.3176	6.5158	3.00	9.00
	T1	12	6.0000	1.85864	0.53654	4.8191	7.1809	3.00	9.00
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	3.8056	3.08748	0.51458	2.7609	4.8502	0.00	9.00
W2_LEAVES	C	12	5.4167	2.84312	0.82074	3.6102	7.2231	3.00	12.00
	T1	12	6.5833	2.19331	0.63315	5.1898	7.9769	4.00	11.00
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	4.0000	3.53755	0.58959	2.8031	5.1969	0.00	12.00
W3_LEAVES	C	12	5.0833	2.15146	0.62107	3.7164	6.4503	2.00	9.00
	T1	12	6.0000	2.79610	0.80716	4.2234	7.7766	2.00	10.00
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	3.6944	3.32797	0.55466	2.5684	4.8205	0.00	10.00
W4_LEAVES	C	12	5.5833	2.15146	0.62107	4.2164	6.9503	3.00	10.00
	T1	12	6.6667	2.30940	0.66667	5.1993	8.1340	3.00	10.00
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	4.0833	3.45067	0.57511	2.9158	5.2509	0.00	10.00
W5_LEAVES	C	12	4.5000	2.87623	0.83030	2.6725	6.3275	0.00	9.00
	T1	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	T2	12	6.4167	2.35327	0.67933	4.9215	7.9119	3.00	10.00
	Total	36	3.6389	3.43222	0.57204	2.4776	4.8002	0.00	10.00
W6_LEAVES	C	12	4.0833	2.99874	0.86566	2.1780	5.9886	0.00	10.00
	T1	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	T2	12	6.5000	2.64575	0.76376	4.8190	8.1810	2.00	11.00
	Total	36	3.5278	3.52531	0.58755	2.3350	4.7206	0.00	11.00
W7_LEAVES	C	12	3.5833	3.23218	0.93305	1.5297	5.6370	0.00	10.00
	T1	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	T2	12	4.0833	2.71221	0.78295	2.3601	5.8066	0.00	9.00
	Total	36	2.5556	2.99947	0.49991	1.5407	3.5704	0.00	10.00
W8_LEAVES	C	12	2.8333	3.12856	0.90314	0.8455	4.8211	0.00	8.00
	T1	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	T2	12	2.8333	2.12489	0.61340	1.4832	4.1834	0.00	7.00
	Total	36	1.8889	2.51598	0.41933	1.0376	2.7402	0.00	8.00

Table B3: Mean and Standard Error for Number of Tillers

Descriptives									
			Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
		N				Lower Bound	Upper Bound		
W1_TILLER	C	12	1.2500	0.45227	0.13056	0.9626	1.5374	1.00	2.00
	T1	12	1.2500	0.45227	0.13056	0.9626	1.5374	1.00	2.00
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	0.8333	0.69693	0.11616	0.5975	1.0691	0.00	2.00
W2_TILLER	C	12	1.1667	0.38925	0.11237	0.9193	1.4140	1.00	2.00
	T1	12	1.3333	0.49237	0.14213	1.0205	1.6462	1.00	2.00
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	0.8333	0.69693	0.11616	0.5975	1.0691	0.00	2.00
W3_TILLER	C	12	1.1667	0.38925	0.11237	0.9193	1.4140	1.00	2.00
	T1	12	1.3333	0.49237	0.14213	1.0205	1.6462	1.00	2.00
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	0.8333	0.69693	0.11616	0.5975	1.0691	0.00	2.00
W4_TILLER	C	12	1.0833	0.28868	0.08333	0.8999	1.2667	1.00	2.00
	T1	12	1.3333	0.49237	0.14213	1.0205	1.6462	1.00	2.00
	T2	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	36	0.8056	0.66845	0.11141	0.5794	1.0317	0.00	2.00
W5_TILLER	C	12	0.9167	0.51493	0.14865	0.5895	1.2438	0.00	2.00
	T1	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	T2	12	1.4167	0.51493	0.14865	1.0895	1.7438	1.00	2.00
	Total	36	0.7778	0.72155	0.12026	0.5336	1.0219	0.00	2.00
W6_TILLER	C	12	1.0000	0.60302	0.17408	0.6169	1.3831	0.00	2.00
	T1	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	T2	12	1.5833	0.66856	0.19300	1.1586	2.0081	1.00	3.00
	Total	36	0.8611	0.83333	0.13889	0.5792	1.1431	0.00	3.00
W7_TILLER	C	12	0.8333	0.57735	0.16667	0.4665	1.2002	0.00	2.00
	T1	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	T2	12	1.4167	0.79296	0.22891	0.9128	1.9205	0.00	3.00
	Total	36	0.7500	0.80623	0.13437	0.4772	1.0228	0.00	3.00
W8_TILLER	C	12	0.6667	0.65134	0.18803	0.2528	1.0805	0.00	2.00
	T1	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	T2	12	0.9167	0.51493	0.14865	0.5895	1.2438	0.00	2.00
	Total	36	0.5278	0.60880	0.10147	0.3218	0.7338	0.00	2.00

Table B4: ANOVA for Plant Height

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
W1_HEIGHT	Between Groups	5477.722	2	2738.861	159.532	0.000
	Within Groups	566.547	33	17.168		
	Total	6044.269	35			
W2_HEIGHT	Between Groups	4960.111	2	2480.055	94.723	0.000
	Within Groups	864.012	33	26.182		
	Total	5824.122	35			
W3_HEGHHT	Between Groups	5939.014	2	2969.507	100.406	0.000
	Within Groups	975.972	33	29.575		
	Total	6914.986	35			
W4_HEIGHT	Between Groups	6592.317	2	3296.159	135.222	0.000
	Within Groups	804.406	33	24.376		
	Total	7396.723	35			
W5_HEIGHT	Between Groups	3305.894	2	1652.947	28.307	0.000
	Within Groups	1927.016	33	58.394		
	Total	5232.910	35			
W6_HEIGHT	Between Groups	3182.597	2	1591.299	25.184	0.000
	Within Groups	2085.208	33	63.188		
	Total	5267.806	35			
W7_HEIGHT	Between Groups	2357.301	2	1178.650	9.071	0.001
	Within Groups	4287.838	33	129.934		
	Total	6645.139	35			
W8_HEIGHT	Between Groups	1630.095	2	815.048	5.106	0.012
	Within Groups	5267.313	33	159.616		
	Total	6897.408	35			

Table B5: ANOVA for Number of Leaves

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
W1_LEAVES	Between Groups	262.722	2	131.361	61.127	0.000
	Within Groups	70.917	33	2.149		
	Total	333.639	35			
W2_LEAVES	Between Groups	296.167	2	148.083	34.454	0.000
	Within Groups	141.833	33	4.298		
	Total	438.000	35			
W3_LEAVES	Between Groups	250.722	2	125.361	30.215	0.000
	Within Groups	136.917	33	4.149		
	Total	387.639	35			
W4_LEAVES	Between Groups	307.167	2	153.583	46.250	0.000
	Within Groups	109.583	33	3.321		
	Total	416.750	35			
W5_LEAVES	Between Groups	260.389	2	130.194	28.281	0.000
	Within Groups	151.917	33	4.604		
	Total	412.306	35			
W6_LEAVES	Between Groups	259.056	2	129.528	24.298	0.000
	Within Groups	175.917	33	5.331		
	Total	434.972	35			
W7_LEAVES	Between Groups	119.056	2	59.528	10.031	0.000
	Within Groups	195.833	33	5.934		
	Total	314.889	35			
W8_LEAVES	Between Groups	64.222	2	32.111	6.735	0.004
	Within Groups	157.333	33	4.768		
	Total	221.556	35			

Table B6: ANOVA for Number of Tiller

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
W1_TILLER	Between Groups	12.500	2	6.250	45.833	0.000
	Within Groups	4.500	33	0.136		
	Total	17.000	35			
W2_TILLER	Between Groups	12.667	2	6.333	48.231	0.000
	Within Groups	4.333	33	0.131		
	Total	17.000	35			
W3_TILLER	Between Groups	12.667	2	6.333	48.231	0.000
	Within Groups	4.333	33	0.131		
	Total	17.000	35			
W4_TILLER	Between Groups	12.056	2	6.028	55.512	0.000
	Within Groups	3.583	33	0.109		
	Total	15.639	35			
W5_TILLER	Between Groups	12.389	2	6.194	35.043	0.000
	Within Groups	5.833	33	0.177		
	Total	18.222	35			
W6_TILLER	Between Groups	15.389	2	7.694	28.477	0.000
	Within Groups	8.917	33	0.270		
	Total	24.306	35			
W7_TILLER	Between Groups	12.167	2	6.083	18.969	0.000
	Within Groups	10.583	33	0.321		
	Total	22.750	35			
W8_TILLER	Between Groups	5.389	2	2.694	11.725	0.000
	Within Groups	7.583	33	0.230		
	Total	12.972	35			

APPENDIX C

Table C1: Plant Height of *Z. officinale* for 8 Weeks

W1_HEIGHT

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T2	12	.0000	
T1	12		26.0833
C	12		26.2500
Sig.		1.000	.995

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W2_HEIGHT

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T2	12	.0000	
C	12		22.9750
T1	12		26.4583
Sig.		1.000	.233

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W3_HEIGHT

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T2	12	.0000	
C	12		26.3750
T1	12		28.0417
Sig.		1.000	.735

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

*C=AB fertilizer, T1=FPJ, T2=FPJ

W4_HEIGHT

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T2	12	.0000	
C	12		27.4167
T1	12		29.8417
Sig.		1.000	.460

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W5_HEIGHT

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05		
		a	b	c
T1	12	6.0000		
C	12		21.3333	
T2	12			29.0583
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W6_HEIGHT

Tukey HSD[a]

		Subset for alpha = 0.05	
TREATMENT	N	a	b
T1	12	6.5833	
C	12		21.6250
T2	12		29.2083
Sig.		1.000	.065

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

*C=AB fertilizer, T1=FPJ, T2=FPJ

W7_HEIGHT

Tukey HSD[a]

		Subset for alpha = 0.05	
TREATMENT	N	a	b
T1	12	6.0000	
C	12		19.7417
T2	12		25.2417
Sig.		1.000	.472

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W8_HEIGHT

Tukey HSD[a]

		Subset for alpha = 0.05	
TREATMENT	N	a	b
T1	12	6.6667	
C	12	13.9917	13.9917
T2	12		23.1167
Sig.		.342	.196

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

Table C2: Number of Leaves of *Z. officinale* for 8 Weeks

W1_LEAVES

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T2	12	.0000	
C	12		5.4167
T1	12		6.0000
Sig.		1.000	.598

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

*C=AB fertilizer, T1=FPJ, T2=FPJ

W2_LEAVES

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T2	12	.0000	
C	12		5.4167
T1	12		6.5833
Sig.		1.000	.364

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W3_LEAVES

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T2	12	.0000	
C	12		5.0833
T1	12		6.0000
Sig.		1.000	.519

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W4_LEAVES

Tukey HSD[a]

		Subset for alpha = 0.05	
TREATMENT	N	a	b
T2	12	.0000	
C	12		5.5833
T1	12		6.6667
Sig.		1.000	.325

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

*C=AB fertilizer, T1=FPJ, T2=FPJ

W5_LEAVES

Tukey HSD[a]

		Subset for alpha = 0.05	
TREATMENT	N	a	b
T1	12	.0000	
C	12		4.5000
T2	12		6.4167
Sig.		1.000	.088

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W6_LEAVES

Tukey HSD[a]

		Subset for alpha = 0.05		
TREATMENT	N	a	b	c
T1	12	.0000		
C	12		4.0833	
T2	12			6.5000
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W7_LEAVES

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T1	12	.0000	
C	12		3.5833
T2	12		4.0833
Sig.		1.000	.870

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

*C=AB fertilizer, T1=FPJ, T2=FPJ

W8_LEAVES

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T1	12	.0000	
C	12		2.8333
T2	12		2.8333
Sig.		1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

Table C3: Number of Tillers of *Z. officinale* for 8 Weeks

W1_TILLER

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T2	12	.0000	
C	12		1.2500
T1	12		1.2500
Sig.		1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W2_TILLER

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T2	12	.0000	
C	12		1.1667
T1	12		1.3333
Sig.		1.000	.505

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

*C=AB fertilizer, T1=FPJ, T2=FPJ

W3_TILLER

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		a	b
T2	12	.0000	
C	12		1.1667
T1	12		1.3333
Sig.		1.000	.505

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W4_TILLER

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05 a	b
T2	12	.0000	
C	12		1.0833
T1	12		1.3333
Sig.		1.000	.167

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W5_TILLER

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05 a	b	c
T1	12	.0000		
C	12		.9167	
T2	12			1.4167
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

*C=AB fertilizer, T1=FPJ, T2=FPJ

W6_TILLER

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05 a	b	c
T1	12	.0000		
C	12		1.0000	
T2	12			1.5833
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W7_TILLER

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05 a	b	c
T1	12	.0000		
C	12		.8333	
T2	12			1.4167
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

W8_TILLER

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05 a	b
T1	12	.0000	
C	12		.6667
T2	12		.9167
Sig.		1.000	.418

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 12,000.

*C=AB fertilizer, T1=FPJ, T2=FPJ