Effect of Fermented Plant Juice (FPJ) & Fermented Fruit Juice (FFJ) on Growth Performance of *Kaempferia parviflora* Cultivated using Bench Fertigation System

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DECLARATION

I declared that this thesis entitled "Effect of Fermented Plant Juice (FPJ) & Fermented Fruit Juice (FFJ) on Growth Performance of *Kaempferia Parviflora* Cultivated using Bench Fertigation System" is the results of my own research except as cited in the references.

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ABSTRACT

Growth of *Kaempferia parviflora* or black ginger were studied in this research. Black ginger plant is usually grown in shifting cultivation which is a traditional cultivation practice that leads to land use issues as well as soil -borne diseases. So in this study, black ginger cultivation using bench fertigation system and soilless crop media such as coir pith, raw and burnt paddy husk were used to replace the traditional cultivation method. Then to support the growth of this black ginger plant, the application of AB fertilizer and supplementation of FPJ and FFJ crops was studied to see its effectiveness on plant height, number of leaves, longest leaf, widest leaf and plant weight. From the study it can be seen that the effect of AB fertilizer application as a control shows less development on crop growth. While application of AB fertilizer with FPJ supplementation in the first 4 weeks had a good effect on the number of leaves with mean readings from 1.40 cm to 2.60 cm. further the use of AB fertilizer with FFJ also showed a good effect on the development of leaf width where the mean reading of the widest leaf in week 6 to week 7 increased from 8.71 cm to 8.90 cm. based on the observations that have been made, the use of AB and FFJ fertilizers showed favourable crop development after 8 weeks of planting. Results for all crop growth parameters were significant except for insignificant plant weight. The results were recorded using Microsoft Excel software, SPSS and analysed using ANOVA.

Key word: *Kaempferia parviflora* (black ginger), fermented plant juice (FPJ), fermented fruit juice (FFJ), bench fertigation system, soilless media

Kesan Jus Tapai Tanaman (FPJ) dan Jus Tapai Buah (FFJ) Terhadap Prestasi Pertumbuhan *Kaempferia parviflora* yang Ditanam Menggunakan Sistem Fertigasi Meja

ABSTRAK

Pertumbuhan *Kaempferia parviflora* atau halia hitam dikaji dalam penyelidikan ini. Tumbuhan halia hitam ini biasanya ditanam secara penanaman pindah yang mana merupakan satu amalan penanaman tradisional yang mendorong kepada isu penggunaan tanah serta penyakit bawaan tanah. Jadi dalam kajian ini, penanaman halia hitam menggunakan sistem fertigasi bench dan media tanaman tanpa tanah seperti sabut kelapa halus, sekam padi metah dan bakar digunakan bagi menggantikan kaedah penanaman tradisional tersebut. Kemudian untuk menyokong pertumbuhan tanaman halia hitam ini, aplikasi baja AB dan suplemen tambahan tanaman FPJ dan FFJ dikaji untuk melihat keberkesanannya terhadap ketinggian tumbuhan, bilangan daun, daun terpanjang, daun terluas dan berat tumbuhan. Daripada kajian tersebut dapat dilihat kesan aplikasi baja AB sebagai kawalan kurang menunjukkan perkembangan pada pertumbuhan tanaman. Manakala aplikasi baja AB dengan suplemen tambahan FPJ pada 4 minggu pertama memberi kesan yang baik pada bilangan daun dengan bacaan min dari 1.40 cm kepada 2.60 cm. Seterusnya penggunaan baja AB dengan FFJ pula menunjukkan kesan baik pada perkembangan kelebaran daun di mana bacaan min daun terlebar pada minggu 6 hingga minggu 7 meningkat dari 8.71 cm ke 8.90 cm. Berdasarkan pemerhatian yang telah dibuat, penggunan baja AB dan FFJ menunjukkan perkembangan tanaman yang menggalakkan selepas 8 minggu penanaman. Keputusan untuk semua parameter pertumbuhan tanaman adalah significant kecuali berat tanaman yang tidak significant. Keputusan tersebut direkodkan menggunakan perisian Microsoft Excel, SPSS dan dianalisis menggunakan ANOVA.

Kata kunci: *Kaempferia parviflora* (halia hitam), jus tapai tanaman (FPJ), jus tapai buah (FFJ), sistem fertigasi bangku, media tanpa tanah

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LIST OF ABBREVIATION

MRP	Multidrug Resistance Protein
A549	Lung cell cancer
PVC	Polyvinyl chloride
NPK	Nitrogen, Phosphorus, Potassium
RM	Ringgit Malaysia
EC meter	Electrical Conductivity
Ft	Feet
cm	centimeter
ml	Millimeter
g	Gram
kg	Kilogram
RBD	Randomized block design
5Ca (NO3) 2. NH4NO3. 10H2O	Calcium ammonium nitrate
KNO3	Potassium nitrate
FeChelate	Iron Chelate
FeEDTA	Ferric EDTA
KH2PO4	Potassium dihydrophosphate
(NH4) 2SO4	Ammonium sulfate
K2SO4	Potassium sulphate
MgSO4. 7H2O	Magnesium sulfate

MnSO4. 4H2O	Manganese (II) sulfate
CuSO4.5 (ZnSO4.7H2O)	Copper sulfate
H3BO3	Boric acid
NH4) 6Mo7O24.4H2O	Ammonium heptamolybdate
FPJ	Fermented plant juice
FFJ	Fermented fruit juice
SPSS	Statistical package science social
ANOVA	Analysis of variances

LIST OF SYMBOL

°C	Degree Celsius
μmol m-2 s-1	Micromole per second and square meter
2: 1: 1	Ratio
μS	Micro Simens
±	Plus minus

CHAPTER 1

INTRODUCTION

1.1 Research Background

Black ginger (*Kaempferia parviflora*), the herbaceous plant, was a member of Zingiberaceae family. Black ginger originated from Thailand and Laos, where it known as "Kurachaidum" or "Kachaidum" or "Thai ginseng". This black ginger could be found in tropical areas such as Malaysia, Sumatra, Borneo Island, and Thailand. The rhizome of this ginger had been long used as folk medicine for many centuries (Wuttidharmmavej. W, 2002). It mainly cultivated in the subtropical region like Thailand and Japan because the soil temperature which exceed 25 ° C was suitable for soil cultivation. The vegetative propagation organ, mainly tuberous roots or rhizomes that was planted in hole with depth 15 cm to 20 cm (Anon, 2011).

Various studies have shown that *K. parviflora* had anti-aging, anti-inflammatory, antiviral, and gastroprotective properties. *K. parviflora* contained a lot of flavonoids and flavonoid glycosides (Sunkyu et al., 2018). They had high selenium and amino acids, as well as polyphenols like anthocyanins and tannins, and were used as flavourings and spices. Black ginger also used in herbal medicines for improving blood circulation and physical strength recovery (Masaki and Naoki, 2011).

The cultivation of black ginger is becoming more vigorous due to many studies released by researchers on the nutrient content found in this ginger plant. At the same time, the cultivation also opened some opportunities for farmers to produce new agricultural products. In order to produce abundant agricultural produce, cultivation methods need to be upgraded to ensure the production of quality and adequate crop yields. Besides, black ginger was an exhaustive crop by nature and had been advised to not grown it in the same field year after year (Gosh, 1984). The majority of cultivated crops requires rotation to maintain soil nutrient availability and eradication of pests and soil-borne diseases (Anon, 2011). R.K. Yadav., et al., (2004) stated that in the North-East region, they also did rotated planting ginger with french bean or soybean where it also could improve the physical condition of soil as well as gave additional income to the farmers.

However, in Malaysia cultivating ginger usually done using shifting cultivation in order to avoid soil borne disease and other soil problems. Therefore, to avoid those problems, cultivating ginger using soilless culture system was an alternativemethod to overcome the problem faced (Yaseer et al., 2012). Apart from that, R.K. Yadav., et al., (2004) also mentioned about the shifting cultivation system which had beena concern nowadays as this system involves crops that are planted for 3 to 5 years in oneplace and then open up new places for new crops. Thus, rise to land used issues could occur, since shifting cultivation required new farming areas every couple of years.

Nowadays, fertigation system and soilless cultivation have mostly been used for the high productions and quality crop yields. There were many types of growing medium or substrates, such as perlite, rockwool, and vermiculite (Raja Harun et al., 1991), coconut fibres, and burnt paddy husks (Ortega et al., 1996), used to grow a variety of crops in soilless production systems. In comparison to conventional methods, yields from soilless cultivation increased 3 to 5 times (Verdonck et al., 1983). Lately this type of cultivation system became popular due to their potential in soil conservation. While the fertigation technology used also facilitate farmers in practising good resource management and producing good yields. The way the technology works were by supplying water and fertilizer at the same time through irrigation system that had been set up. However, frequent monitoring had to be done when it comes to technology to assure the fertigation system runs well and kept the crop alive.

Usually, the fertilizer used were the mixture of nutrient stock solution A and B which contained macro and micro elements. Thus far, this fertilizer that most farmers used for cultivation through fertigation. The fertilizer given supports plant to develop and grow. In addition, supplements for crops are also given to encourage crop growth. Fermented Plant Juice (FPJ) and Fermented Fruit Juice (FFJ) were used as additional supplements for plant growth. Fermented Plant Juice (FPJ) and Fermented Fruit Juice (FFJ) are organic fertilizers that help vegetable crops grow and develop. Applying fermented plant juice (FPJ) to vegetable crops had promotes good plant development and vitality (Juane C.G., 2004). While according to Tagotong, M.M., (2014), fermented fruit juice was a good source of plant nutrients in improving the physical qualities of soils. Furthermore, the used of fertilizers had also increase the farms or soils essential properties, which responsible on the enhanced of plant growth, and development.

1.2 Problem Statement

Usually, black ginger (*Kaempferia parviflora*) rhizomes are planted directly in the soil using a shifting cultivation system. However, this shifting cultivation leads to the occurrence of some problems in ginger cultivation. The first problem is the opening up of new land areas for new agricultural activities, which will lead to overclaiming of forest areas.. Therefore, a bench fertigation system has been established to overcome the problem. In addition, the system is also equipped with automatic irrigation and fertilization facilities that can save farmers time and energy. Next to overclaim of forest areas, soil-borne diseases are the major threat tp ginger cultivation which causes ginger rot and reduce the yield (Masaki and Naoki, 2011). Then, to avoid this problem, cultivation using soilless media such as coir peat, raw paddy husk, and burnt paddy husk was done to replace old fashion planting way.

Besides, dumping of agricultural waste such as vegetables and fruits is a common problem in agriculture. This occurs due to the mass production and poor postharvest handling (Oshunsanya and Aliku., 2016). Therefore, the initiative taken is to convert agricultural waste into supplement products for crops such as fermented plant juices (FPJ) and fermented fruit juices (FFJ) (Zamora and Calub., 2016). Thus, the potential of soilless cultivation system using bench fertigation system to overcome land use problem and increase the growth rate of black ginger has been studied.

1.3 Hypothesis

H_0: There is no significant improvement on the growth performance of black ginger sprayed with the fermented plant juice (FPJ) and fermented fruit juice as booster (FPJ).

H_1: There is significant improvement on the growth performance of black ginger sprayed with the fermented plant juice (FPJ) and fermented fruit juice as booster (FPJ).

1.4 Objective of Study

The first objective of this study was to measure the growth performance of black ginger (*Kaempferia parviflora*) sprayed with of fermented plant juice (FPJ) and fermented fruit juice (FFJ) as additional supplement for plants. The second objective of this study was to identify the best additional supplement of plant for the growth of black ginger.

1.5 Scope of Study

In this study, *Kaempferia parviflora* seedlings were grown using bench fertigation system which technically has provided a wide growing space for horizontal growth of rhizomes. Cultivation of black ginger involved the use of selected crop media namely coir pith, raw paddy husk, and burnt paddy husk as alternative planting media (Yaseer et al., 2018). In addition, to support the growth of ginger crops, fertilizers were also applied to whole plants. Types of fertilizer commonly used in fertigation was a mixture of soluble fertilizers A and B which typically contain NPK (Nitrogen, Phosphorus, Potassium) because the fertilizer provides nutrients for plants to carry out the metabolism process (Miftah et al., 2020). Moreover, fermented plant juice (FPJ) and fermented fruit juice (FFJ) were used as supplement to improve crop development. The observations from this study were taken in 8 weeks and the records are presented as the result in this study.

1.6 Significance of Study

According to a study once reported by Robin et al., (2019), cultivation using a fertigation system is able to control soil-borne diseases caused by direct cultivation in the soil. However, by using this system, soilless planting media were used such as burnt paddy husk produced from carbonization which acts as a soil amendment, fertilizer production, and activated carbon (Pavan, 2019) while coir pith keeps the soil loose and airy, which promotes root growth. Furthermore, the conversion of agriculture waste into additional plant supplement FPJ and FFJ had reduced the environmental issue caused by the dumping of agricultural waste. So, the outcome of this study was able to address several issues such as land use, semi-automated fertigation system that can save farmers' time and energy as well as reduce the occurrence of disease afflicting. A part of that, the environmental issues also can be reduced and new agricultural products can be produced.

1.7 Limitation of Study

There are some restrictions that limit the scope of this research project, such as the short research period, which runs from October to December. Furthermore, because the rainy season lasts for four months, the humid climatic conditions impact the growth of black ginger. Moreover, the initial growth of crops are non-uniform which has an impact on its growth and development.

CHAPTER 2

LITERATURE REVIEW

2.1 History of Zingiberaceae Family (*Kaempferia parviflora*)

The Zingiberaceae family has about 53 genera more than 1200 species. There is a Zingiberaceae species named *Kaempferia parviflora* which also known as black ginger or Kra-chaiDum (in Thai). Mostly, this kind of ginger can be found planted in Thailand. Thus, the country is commonly considered as a centre of diversity and distribution in Asia (Npporncharoenkul et al., 2017). A part of that, it also can be found in Asia, Africa, and America's tropical regions. This species has deep purple-colour rhizomes that morphologically represents normal ginger. Therefore, perennial, aromatic, tuberous, and non-tuberous rhizomes were the taxonomic classifications for these species (Gelila et al., 2019). In addition, Table 2.1 shows the scientific clarification of black ginger.

Table 2.1: Scientific Clarification of *Kaempferia parviflora*

Kingdom	:	Plantae
Clade	:	Tracheophytes
Clade	:	Angiosperms
Clade	:	Monocots
Clade	:	Commelinids
Order	:	Zingiberales
Family	:	Zingiberaceae
Genus	:	*Kaempferia*
Species	:	*K. parviflora*

Source: Wikipedia (2022)

In black ginger cultivation, it needs warm, humid climate, well-drained soils such as sandy, clay loam, red loam or laterite loam to grow. North-Eastern region grown ginger as rainfed crop while other country grown as rainfed and irrigated crop. This crop also known as exhaustive crop by nature and not recommended to grow in the same area year after year (Gosh, 1984) because there is no guarantee the plant were not exposed to soil born disease. Furthermore, this plant must be kept evenly hydrated while in developing stage. However, it is necessary to keep it dry while it is dormant. Plant rhizomes will rot if it were too wet when dormant. However, Catherine et al., (2016) has stated that the level of shading plays an important role in the cultivation when rhizome is at the initial stage of development.

Figure 2.1: *Kaempferia parviflora* plant (Info Sihat, 2021)

2.1.1 Characteristic of *Kaempferia parviflora*

Masaki and Naoki, (2011) wrote that the black ginger is a rhizome-forming herb with a 20 cm seedling height. Then it will grow and reach up to 30 cm until 40 cm in height. The rhizomes are small and dark purple in colour, hence the name black ginger. The rhizome is normally 8-16 cm long, small, rounded at the base, with simple green leaves. In addition, the sapling also has a short, channelled leaf stalk and also a few flowers at the centre of the lever.

They also reported that, it is narrated that this *Kaempferia parviflora* sapling should have green scalpel-shaped bracts measuring 2.5 cm. The petals of this sapling are also longer than the bracts. There is also a corolla tube measuring 3 cm which is green in colour and has an ascending and concave segment with approximately 1 cm in length. Then, the sapling also has a lip size of 0.75 cm to 1.0 cm, sub-emarginated on the anther part of the crest and wide along. It will grow to a height of 30.5 cm if given the proper temperature and light (Puangpen Sirirugsa., 1992).

2.1.2 Medicinal Properties

Kaempferia parviflora or black ginger has become alternative medicinal plants that contain active compounds which are able to disrupt homeostasis of cancer cells. Black ginger rhizome is used in traditional medicine and act as anti-gastric ulcer, anti-allergic, anti-plasmodial, and anti-cancer. Specific studies on black ginger as an anti-cancer have shown black ginger suppresses multidrug resistance-linked protein (MRP) in A549 cells (lung cancer) (citation). In addition, according to S. Potikanond et al., (2017) “black ginger causes apoptotic cell death and enhanced paclitaxel or doxorubicin treatment in promyelocytic leukemia cancer cell lines”.

Their rhizomes are the most commercially useful plant parts, as well as a rich source of biologically active phytoconstituents (Jatoi et al., 2007). According to (Yoshino. S et al., 2018) this ginger rhizome has been used traditionally in improving blood flow, treat inflammatory, allergic, and gastrointestinal disorders. It has also been reportedto be beneficial for anticholinesterase, anti-inflammatory, spasmolytic, gastric ulcerrecovery, antioxidants, and for additional vasodilator effects as a regulation of adipocytedifferentiation. Black ginger is also extracted as a dietary supplement in which studies conducted on rats it works to inhibit weight gain, body fat accumulation and glucose intolerance. According to other studies, intake of this supplement is recommended to increase energy and fat consumption. So, based on the above statement, black ginger supplement is useful to reduce body fat in human body.

2.2 Use of Fertigation System

Fertigation is a technical innovation of fertilization and irrigation where this resulted to adoption of fertigation system. The system that requires soilless media such as coir pith, perlite, burnt paddy husk and other substances that can be used to replace soil. In this system, soluble fertilizer has been dissolved in irrigation water then channelled the plant nutrient together with watering for a direct uptake bythe crops' rootsfor plant optimal growth (S. Mahamud et al., 2012). This is a drip irrigation system that uses the latest innovative culturing methods to increase efficiency in the use of fertilizersas well as increase crop yields. In fertigation systems, the essential elements are supplieddirectly to the active root zone, thus minimizing nutrient loss, helping to increase productivity and yield quality, and the risk of environmental pollution can also be reduced.

Special equipment used in fertigation systems. The type of fertigation system is differs according to the type of crop, the type of irrigation system used, and the type of fertilizer used (Shukla et al., 2018). However, fertigation system can save the cost of production because it does not require the repeated land preparation cost, weeding, and manual fertilizer applications like the conventional method since it operates automatically by using timer which can reduce work force.

This system is proven to be effective and efficient in the cultivation of leafy vegetables and fruits such as cucumbers, tomatoes, milk melons and more. For ginger cultivation, there is cultivation done in lowland areas using fertigation method. As a result, the average yield of ginger rhizomes increased up to two to three times compared to conventional methods. The fertigation of ginger allows ginger to be grown in the same area repeatedly for many years (Yaseer and Mohamad., 2012). Therefore, fertigation system is the best method for ginger cultivation in producing young and mature gingers. In fact, to produce high yields it does not depends on the large planting areas, it depends on the improvement of planting system used and the application of good management practices in gaining high yield agriculture produce (Sanyang et al., 2008).

2.2.1 Benching Fertigation System

Bench systems come in many types and are commonly used in greenhouses. There are types of elevated bench systems and there are also those that use greenhouse floors. The function of this bench system is to support plant material only. In addition, to allow crop irrigation and crop transportation around the greenhouse usually use hybrid system facilities. However, bench systems have different production surfaces for each type. Here we introduced several bench systems commonly used in greenhouses (M.R. Evans., 2014). The first bench system was stationary benches (D.L. Ingram et al., 2017). Stationary benches are made of various materials such as concrete blocks, wood, steel, aluminium, or even hard plastic. The surface of the bench is made of wood, wire, wire cage, expanded metal, snow fence, chain link fence, tidal irrigation tray, irrigation trough or can use other types of materials. The efficiency of this bench in the use of low space with little flexibility. The second bench used in the greenhouse is a rolling bench (E. A. van Os., 2007). This bench has a surface mounted on a support structure to facilitate the work of transferring the surface from one place to another in the greenhouse. With this bench it can reduce pedestrian walkways as well as the efficiency of space use can be improved.

However, its use reduces access to plant material. The third bench system used in greenhouses that stated in same article above is a movable bench designed to change the position of the greenhouse at a particular time of the growing season. This bench system is a simple and temporary system that is not installed on the greenhouse floor. Typically the structural construction of these bench systems is made of concrete blocks, aluminium, steel, or wood while the surfaces use wire, wire fences, wire cages, snow fences, or other low cost and portable materials.

Apart from that, certain types of benches are applied in greenhouses, such as wire cage benches, which can be simple wire or complicated systems. However, everything is been set up for the container to be inserted into the wire openings. After that, the container is held in place by the wire. This is usually a low cost, simple raised bench system. The wire's openings, on the other hand, must be the same size as the container. Because the cage maintains the container in place and prevents the plant from falling over. These benches are most typically used for planting tall or heavy top potted plants (M.R Evans., 2014). Next, ebb-and-flow benches (Joseph R., 2017) connect a tiered bench design with a closed circulatory irrigation system. This bench system can be used as either a stationary or a moving bench. The major feature of this bench is a tray made of plastic or aluminium that is toughened in length and width based on the desired bench proportions and serves as the bench's surface. The fertiliser will be emptied through the tray outlet for distribution. Moreover, trough is a narrow linear bench made of aluminium, plastic, or PVC. This is mainly made to hold plants in containers with open and shallow face channels that are placed in troughs. It is positioned at a low elevation to allow water or fertilizers solution to flow freely. It is often applied in hydroponics and breeding systems (Y. Zheng et al., 2004).

2.3 Types of Cultivation Media

The fertigation system utilized treated planting media to replace soil. The use of treated planting media in fertigation system has long been practiced as many crop problems can be solved by this cultivation method. Therefore, the planting media used to replace the soil in ginger cultivation were coir pith and burnt paddy husk as reported by (Yaseer., 2012) . In order to grow black ginger plant, these two types of media were used because the sources of organic nutrient contained in it very helpful in plant growth as in burnt paddy husk has the source of carbon which is used as a soil amendment, fertilizer production, and activated carbon (Pavan, 2019). While cocopeat kept the soil loose and airy, which promotes root growth. Once root growth improved, it leads to the improvements of plant growth and yield. Both media were used to replace the soil in this study.

2.4 Fertilizer Application

Factors in effective fertilizer application includes timing, quantities, and concentration are easily managed with fertigation. It allows for more effective application of water-soluble fertilizer and other chemicals, as well as irrigation, in the active root zone of the crop. Common fertilizer that is often used in fertigation system is mixture of fertilizer A and B which contain NPK (Nitrogen, Phosphorus, and Potassium) sources. Fertilizers are needed for the growth of all plants and crops, including black ginger. It is important to provide them with phosphorus. Masaki and Naoki, (2011) also report that sufficient phosphorous supply will induce the plant to produce big rhizome.

2.4.1 Composition of Fertilizer

Fertilizers are a source of nutrients for plants to perform metabolic processes (Miftah et al., 2020). Therefore, providing complete and adequate fertilizer is very important for the crop because the nutrients absorbed will be converted into energy and increase the growth of the crop (Telaumbanua et al., 2016). Usually the fertilizer used in the fertigation system is a mixed solution fertilizer A and B. This fertilizer is one of the nutritional formulas made specifically for the cultivation of crops by fertigation and hydroponics.

The fertilizer mixture is based on formula A and formula B. Formula A contains calcium ammonium nitrate {5Ca (NO3) 2. NH4NO3. 10H2O}, potassium nitrate (KNO3), Fe-chelate and Fe-EDTA. While in formula B the content is potassium dihydrophosphate (KH2PO4), ammonium sulfate ((NH4) 2SO4), potassium sulfate (K2SO4), magnesium sulfate (MgSO4. 7H2O), manganese (II) sulfate (MnSO4. 4H2O), copper sulfate (CuSO4), zinc sulfate heptahydrate (ZnSO4.7H2O), boric acid (H3BO3) and ammonium heptamolybdate ((NH4) 6Mo7O24.4H2O) (Sutiyoso, 2003). Preferably, fertilization of the crop is done once every 2 weeks with the right quantity to be applied to the crop to achieve growth.

2.5 Fermented Plant Juice (FPJ)

FPJ is used to treat seeds and soil and is used as plant food. Plants such as the young shoots of vigorously growing plants are used and fermented for about 7 days with the help of brown sugar. Through an osmotic process, brown sugar produces juice from plant material. In addition, brown sugar serves as a food source for microbes that carry out the fermentation process. Then, a weak alcohol is produced during fermentation that extracts chlorophyll to dissolve in ethanol and other plant components. The fermentation product is non-toxic and ready for crop use (S.A. Miller et al., 2013).

In addition, FPJ contains an enzyme solution rich in useful bacteria that is suitable for use for plants and animals as it is a liquid fertilizer rather than a plant extract solution. However, this is a dynamic practice that helps poor farmers to obtain fertility and pest control from plant material by using simple extraction methods. So to get more effective yields and good yields, FPJ needs to be tested for its usefulness on different crops. Besides plant products to make FPJ also need to be different (Eden A. Alam., 2021).

2.6 Fermented Fruit Juice (FFJ)

Fermented fruit juices contain nutrient activating enzymes and are effective in agriculture. It can be used for crops, livestock, and humans. Fruits such as bananas, papayas, mangoes, grapes, melons, apples and others are used as the main ingredients in the production of this natural fertilizer. Usually, FFJ is used for plant fertilization as well as to increase agricultural yields. This FFJ is also good for soils where it benefits the microbiome in the soil and increases soil fertility (Reickenberg and Pritts., 1998).

In addition, FFJ is used as a leaf fertilizer for corn crops where it can improve the quality of corn yields. Direct spraying on the leaves speeds up the process for nutrients to be absorbed directly compared to direct fertilization which takes time to be absorbed by the tree (Naz et al., 2011). However, a report by Alam, Md. Amirul (2017) pineapple FFJ gave better result in total leaf area rather than banana FFJ.

CHAPTER 3

METHODOLOGY

3.1 Location of Study

Strategic locations should be used to plant Kaempferia parviflora as it requires an area with a suitable ambient temperature between 20 to 25 ° C with illumination of 25 to 35 μmolm−2 s−1 which can only be achieved with synthetic or artificial lighting (Anon, 2011). So the location chosen to conduct this research was in the nursery of Universiti Malaysia Kelantan which located at Jeli, Kelantan. This nursery has been specially prepared for students who will undertake crop-based research projects

3.2 Materials

Preparation of materials are very important in conducting research activity. The main material that has been prepared was rhizomes of *Kaempferia parviflora* or black ginger (Tong and Searle, 2018). Then, the other materials that has been prepared were planting media and fertilizers. The media used in this project is a mixture of coir pith, raw paddy husk and burnt paddy husk. While the fertilizer applied to black ginger plants through fertigation system is a combination of fertilizers A and B. *Kaempferia parviflora* cultivation is made using bench fertigation system where the preparation for fertigation of this bench is black net, PVC pipe, and blue C- Channel batten to make the frame. While the bench itself is made of concrete material.

For the fertigation system, it is equipped with the same equipment as other fertigation, namely 2 storage tanks of which 1 to store water and 1 to store fertilizer. In addition, pumps, supply lines, memory channels, filters, solutions for sterilization systems, monitoring probes and drippers were attached to storage tank in these fertigation systems (Evans, 2008). A part of that fermented plant juice (FPJ) and fermented fruit juice (FFJ) has been prepared in this project in order to study the effectiveness of it as additional plant supplement on the growth and development of black ginger.

3.3 Research Methodology

3.3.1 Preparation of *Kaempferia parviflora* rhizomes

Figure 3.1: Sprouting of black ginger after 3 weeks

Kaempferia parviflora rhizomes or black ginger are purchased online fromreliable suppliers. 1 kilogram (kg) of black ginger rhizomes is bought for RM80. The black ginger rhizomes were cut according to the estimated gram (g) weight of 11g to 14g.Then it is cleaned with running water and soaked in clean water for 1 hour. After 1 hourit is dried and then sown into a prepared bench. The nursery period usually takes 1 monthfor the rhizomes to produce shoots and complete into seedlings. Through a report writtenby Tong and Searle, (2018) the characteristics of the seedlings used for the planting process are seedlings that have a height of 20 cm with a leaf size of 8 cm to 16. cm long.For seedlings, the leaves are very thin and easily torn and rounded at the base. When it iscomplete to be a seedling, it will be transferred into a new bench equipped with a fertigation system. The planting period to achieve the target of young rhizomes took fourmonths as the research project was allowed to operate from October to December only. During that period, the objectives of the study on crop growth and development were successfully achieved.

3.3.2 Preparation of planting medium

Plant media used to plant black ginger seedlings are coir pith, raw paddy husk and burnt paddy husk. The three types of media will be mixed into one bench with a ratio of 2: 1: 1 where the ratio represents 2 bags of coir pith, 1 bag of raw paddy husk and 1 bag of burnt paddy husk. However, coir pith needs to be washed or rinsed first before being mixed with other media. Coir pith should be washed or rinsed with running water until the color of the washing water becomes clear. The purpose is done because coir pith is highly acidic if not washed first and can affect growth (D.M. Jeyaseeli and S.P. RAJ., 2010). Finished washing the coir pith, the other two media can be mixed together with the washed coir pith and mixed evenly in the bench. Thereafter, the media should be left for a day before the planting process is carried out for the purpose of media availability.

Table 3.1: Types of planting media used in research project.

Types of Planting Media	**Quantity**
Coir pith	2 bags
Raw paddy husk	1 bag
Burnt paddy husk	1 bag

3.3.3 Bench fertigation system

A bench fertigation system was selected to study soilless cultivation techniques for planting black ginger. This bench fertigation system is built using concrete material to form a table. It is then installed with a C-Channel batten to form a frame and PVC pipes to channel water are tied together with the iron frame. This bench is rectangular in shape with a height of 1 meter above the ground. When the frame section is ready, a black net is placed on top of the concrete slab. This black net is used to hold the planting media, this preparation is used to replace the polybag. The microtube and dripper are connected to the PVC pipe section found on the frame of the bench system for irrigation purposes (M.R. Evans, 2008). This fertigation function is used to distribute fertilizer and water according to a schedule (Yadav et al., 2017). The bench fertigation system differs from other fertigation systems in terms of the use of the bench as a seeding platform, while the other uses polybags. This fertigation bench also helps save planting space when compared to polybag fertigation. The wide horizontal platform found in this bench fertigation system can accommodate the growth habit of horizontal black ginger rhizomes.

3.3.4 Fertilizer preparation

The fertilizer used in the cultivation of black ginger is a combination of fertilizers A and B. This fertilizer is a soluble fertilizer and should be stored in large barrels. Both fertilizers will be mixed into the storage tank of the fertigation system when required for fertilizing the black ginger crop. For black ginger fertilization, it should be given according to the age of the plant and it should be measured using EC meter. at the seedling stage after 2 weeks of transplantation, the EC meter reading of fertilizer is 1.8ms equivalent to 300ml for each fertilizer A and B. for subsequent fertilization is done in the 4th week with EC meter reading of 2.4ms equivalent to 700ml for each fertilizer A and B Then, the distribution of fertilizer to the crops is made through a dripper that has been placed near each crop (S.M. Yasser., 2016). Fertilizer application time is for 5 minutes twice a day, morning and evening. For good plant growth fertilization should be done once every 2 weeks. This fertigation method facilitates fertilization along with irrigation where it operates automatically using a timer.

3.3.5 Preparation of FPJ and FFJ

The purpose of preparation of FPJ and FFJ is the same to produce additional supplements for black ginger plants. Even so, according to the report by Alam, Md. Amirul, (2017) FPJ and FFJ are used as foliar fertilizers in fertigation systems to increase and improve the yield and quality of tomato crops. However, in this study on black ginger crop is to find out between FPJ and FFJ which is more suitable for the growth and development of black ginger. For the preparation of FPJ, the ingredients used are from glaze sources such as mustard, water spinach and green spinach. While for FFJ, it uses sources from fruits such as bananas, papayas and pumpkins. Then, additives such as molasses are used to ferment vegetable and fruit ingredients. Besides, brown sugar can also be used according to (S.A. Miller., 2013). The yield of vegetable material fermented using molasses for a week was FPJ and the yield of fruit fermentation with molasses was FFJ. Fermentation for both of these plant supplements is done in a closed black container in the nursery area where black ginger is grown. The product were filtered first and should be separated from the material that decomposes. The result of the filtration produces a thick brown liquid. For its use, it needs to be mixed with water before being applied to plants using the formula 10ml FPJ or FFJ mixed with 500ml clean water. FPJ was applied directly on the plant surface for the first 4 weeks and the last 4 weeks were sprayed with FFJ using the same method.

3.3.6 Experimental Design

This experiment was conducted to study the effect of fermented plant juice (FPJ) and fermented fruit juice (FFJ) on growth performance of *Kaempferia parviflora* or black ginger cultivated using bench fertigation system. In this study, the experiment was carried out by using a randomized block design (RBD). The planting materials used were black ginger rhizomes which has been sown for 1 month to produce seedlings in germination media on bench fertigation system sized 8 ft x 3 ft. After the seedling produced, it has been transferred to another fertigation bench that was filled with planting media (coir pith, raw paddy husk and burnt paddy husk). There are 20 seedlings represent 10 controlsand 10 treatments which for treatments it involves the use of FPJ sprayed to the plant at first 4 weeks and FFJ was sprayed 4 week after FPJ. For planting distance between plants,it was shown in figure 3.1. Summary of the control and treatment involved in this study shown in table 3.2 where the total of plant was 20 and involves the use of FPJ and FFJ.

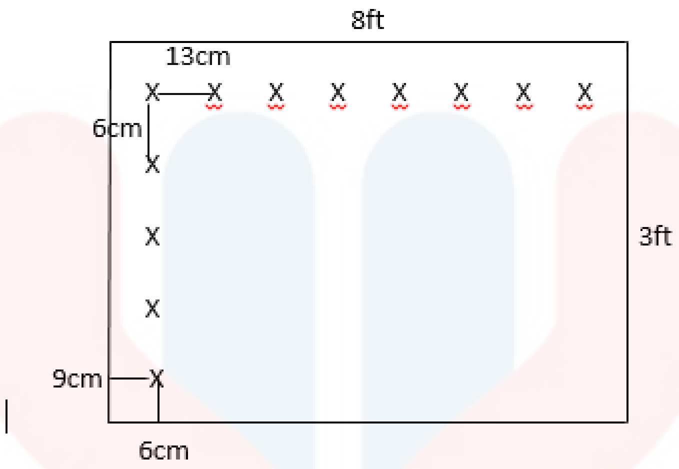

Figure 3.2: Planting Distance between plant

Table 3.2: Summary of control and treatment plant treated with FPJ and FFJ

PLANT	REPLICATION	TREATMENT	WEEK
Control	10	AB fertilizer	8 weeks
Treatment	10	AB fertilizer + FPJ	4 weeks
		AB fertilizer + FFJ	4 weeks
Total of plant = 20			

3.4 Data Collection

In the data collection and analysis section, data was collected every week until week 8 after *Kaempferia parviflora* seedlings are planted. The data on plant height, number of leaves, length of leaves, width of leaves and rhizome weight for each plant has been observed and recorded.

3.5 Growth Parameter

3.5.1 Plant height

Measurements for plant height has been taken using a measuring tape. Height is measured starting at the soil surface part up to the shoot part.

3.5.2 Number of leaves

For the number of leaves, only the quantity of the number of open leaves has been counted.

3.5.3 Length of leave

The length of leaves has been measured by using measuring tape. Measurements were taken only for the longest leaves to determine its growth rate and development.

3.5.4 Width of leave

The measurement of leave was taken using the measuring tape. Measurements were taken only for the widest leaves

3.5.5 Fresh weight of rhizome

The net weight of the *Kaempferia parviflora* rhizome was calculated at the end of the research. In this research, weight of whole young ginger plant were targeted. After 4 months, the black ginger plant were harvested and weighted using a weighing scale. Black ginger net weight for control and treatment were also recorded and evaluated.

3.6 Data Analysis

The data of the experiment has been collected and were analyzed using ANOVA and SPSS software. From that, it will shows the significance and distribution of variance and mean of the data to determine between FPJ and FFJ which the most effective for the ginger growth and development using bench fertigation system. One-way ANOVA was used in this study to determine the growth development of black ginger.

3.7 Research Flowchart

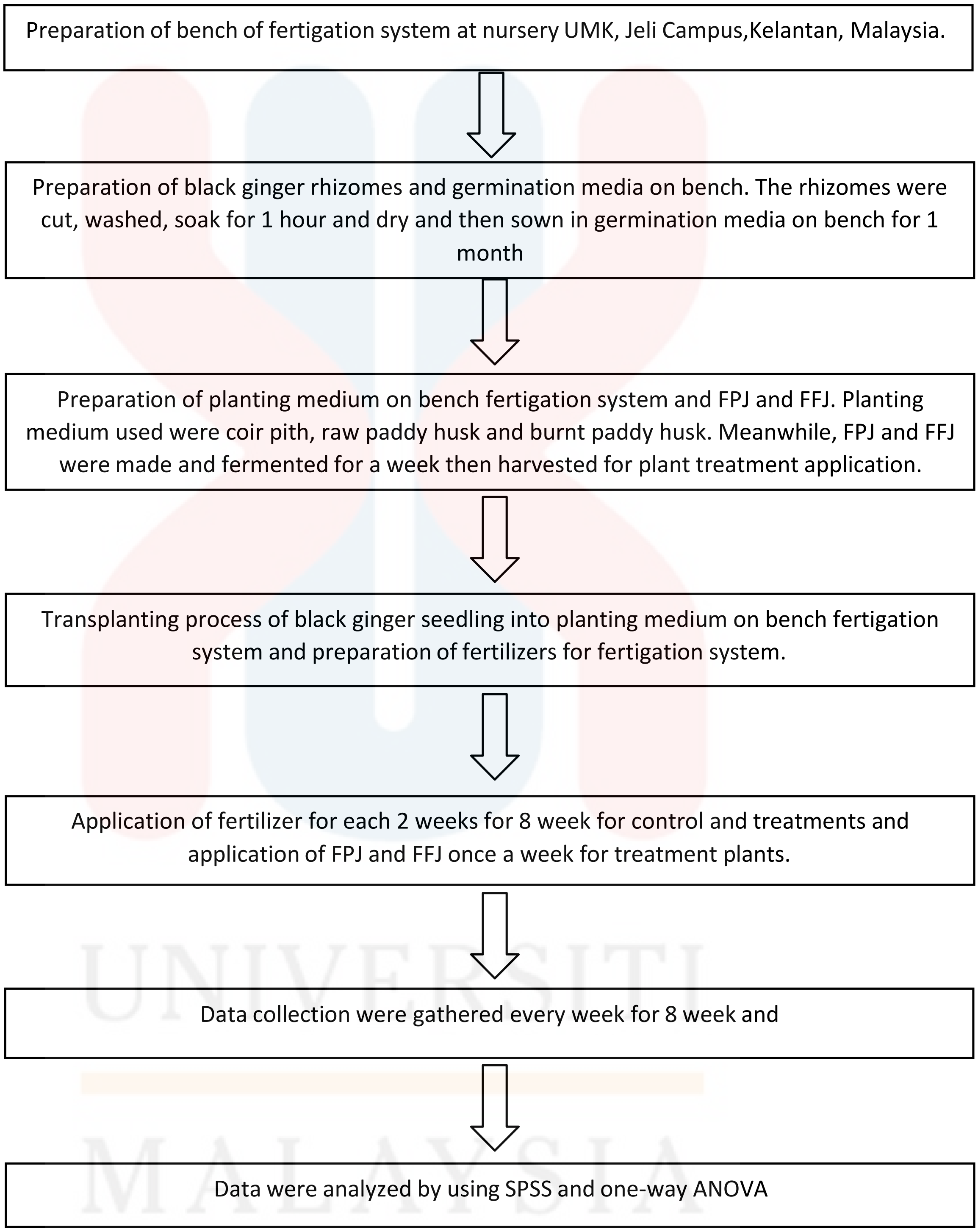

Figure 3.3: Research flowchart of study

CHAPTER 4

RESULT AND DISCUSSION

4.1 Growth of *Kaempferia parviflora* rhizomes

The planting material used in this experiment was black ginger rhizomes. Black ginger rhizomes or black ginger seedlings are difficult to obtain due to their unfavorable cultivation compared to regular ginger. Usually, this black ginger is grown as a private crop and is not commercialized. This fact were also reported by R.K. Yadav., (2004) where the people of Mizoram grow black ginger only for their own use and sold at a very high price. It is sold at a very high price due to the limited cultivation or production of black ginger. In this research project, it is proven that the price of black ginger rhizomes were high where 1 kg of black ginger rhizomes is available at a price of RM80 from an online store because there is no nearby source that grows or cultivates black ginger. Therefore, due to the limited production of black ginger this has led to this research project being carried out.

Leading up to the research project, black ginger was planted using rhizomes. The black ginger rhizomes need to be sprouted first until they become seedlings in the bench that contains the germination media. The time taken for germination of rhizomes to seedlings is for 1 month. During that period, at the beginning of 2 weeks of planting the germination is not uniform where there are several rhizomes that have produced leaves. Due to the non -uniform initial germination, then in the 1-month period only a few rhizomes show complete seedling growth. So, the complete seedlings are transferred to a new bench that contains special planting media which is a mixture of coir pith, raw paddy husk and burnt paddy husk.

The black ginger seedlings were arranged in RBD to represent the control crops and treatment crops and it shows on Figure 4.1. In this study, the control crops were only given AB fertilizer which is a commercial fertilizer that is often used in various types of cultivation. Meanwhile, the treatment crops were given AB fertilizer similar to the control crops. However, what differentiates treatment crops from control crops is the additional supplementation of FPJ and FFJ crops to treatment crops. The purpose of this study was to see which growth of ginger plant is better between control crop and treatment crop. Observations on plant growth were made daily for 8 weeks where the parameters of plant height, number of leaves, longest leaves, widest leaves and weight of young rhizomes were observed.

Figure 4.1: Black ginger seedling represent control and treatment

4.2 Performance of *Kaempferia parviflora* growth base on parameter:

4.2.1 Height of Plant

Based on (Figure 4.2) shows the growth graph for the height of control crops and treatment crops using FPJ in week 1 to week 4 were recorded where it can be seen that the height of control crops preceded the height of treatment crops given additional supplementation of FPJ crops. The height readings for both control and FPJ treatment increased from week 1 to week 4. The increase can be seen where from week 1 to week 4 the mean reading for control increased from 25.34 cm to 28.44 cm and treatment increased from 24.22 cm to 25.38 cm.

Table 4.1: Growth performance of plant height between control and T1

WEEK	SAMPLE	
	C	**T1(FPJ)**
1	25.34 ± 7.468	24.22 ± 4.886
2	27.73 ± 5.297	24.72 ± 4.691
3	27.97 ± 4.968	24.93 ± 4.794
4	28.44 ± 4.6	25.38 ± 5.541

*C (control) = AB fertilizer, T1= AB fertilizer + FPJ

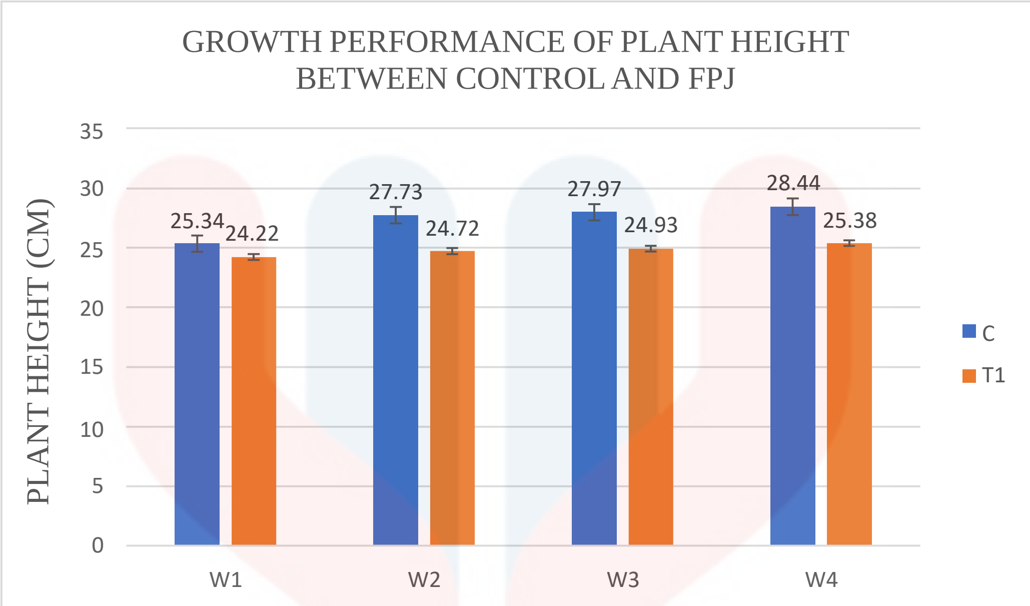

Figure 4.2: Graph shows the growth performance of plant height between control and FPJ

For the growth graph for the height of control and treatment of FFJ at week 5 to week 8 is shown in (Figure 4.3). Through the graph it can be seen that the height of the control crop is still higher compared to the height of the treatment crop sprayed with FFJ crop supplement. However, there was a decrease in the control sample where the mean reading from week 5 to week 8 was from 28.42 cm to 25.47 cm. Another with FFJ sprayed treatment samples where the mean reading decreased from week 5 to week 7 from a reading of 26.28 cm to 24.25 cm and at week 8 the reading increased to 25.18 cm.

Table 4.2: Growth performance of plant height between control and T2

WEEK	**SAMPLE**	
	C	**T2(FFJ)**
5	28.42 ± 4.702	26.28 ± 7.115
6	28.1 ± 5.024	26.22 ± 6.136

7	25.68 ± 10.077	24.25 ± 5.73
8	25.47 ± 9.969	25.18 ± 7.23

*C (control) = AB fertilizer, T1= AB fertilizer + FFJ

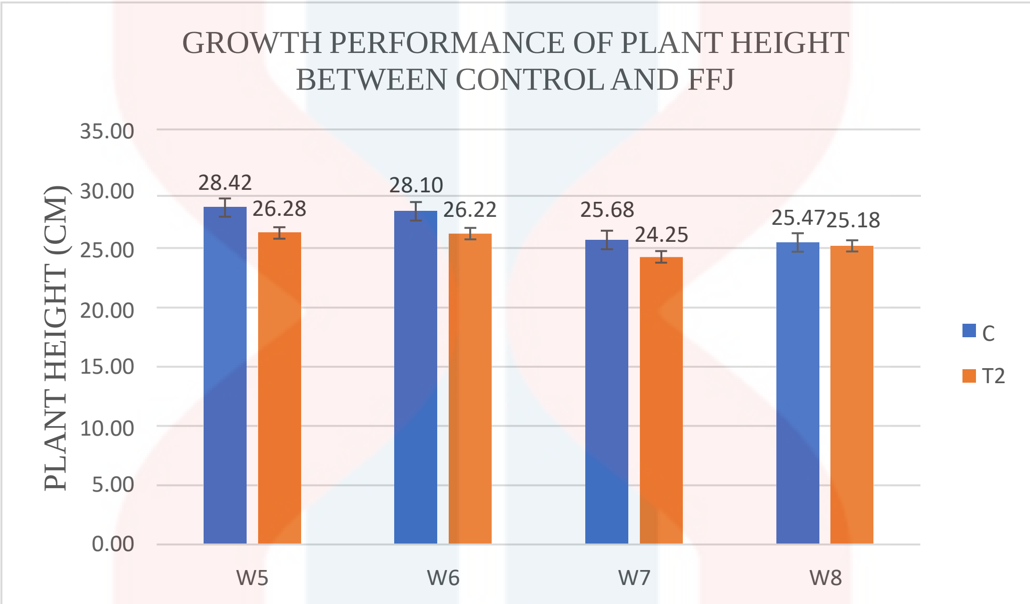

Figure 4.3: Graph shows the growth performance of plant height between control and FFJ

From both grafts of plant height, the control was higher compared to the height for both FPJ and FFJ treatments. Here it can be observed that in week 1 to week 4, the treatment plants sprayed with FPJ occur a decrease in the height of the plant. However, it can be seen in week 5, for treatment plants sprayed with FFJ, the mean height reading decreases when entering weeks 6 and 7, and increases again in week 8. So, through observations made this height decrease is due to pest attacked, such as caterpillars that eat the tips of leaves and cause a decrease in plant height. In addition to pest attacks, there are some plants that experience burns on the tips of the leaves that are likely due to excess fertilizer applications.

4.2.2 Number of Leaves

Next, growth data for the number of leaves for control crops and treatment crops sprayed with FPJ can be seen on the graph (Figure 4.4). On the graph it can be seen that the number of leaves for FPJ treatment and control in week 1 to week 4 is increased. However, the number of leaves in the control was higher than in the FPJ treatment. The number of leaves in week 1 to week 4 for control increased from a mean reading of 1.9 cm to 2.70 cm and for treatment from 1.40 cm to 2.60 cm.

Table 4.3: Growth performance of number of leaves between control and T1

WEEK	**SAMPLE**	
	C	**T1(FPJ)**
1	1.9 ± 0.74	1.4 ± 0.52
2	2.2 ± 0.92	2.0 ± 0.67
3	2.5 ± 0.85	2.4 ± 0.70
4	2.7 ± 0.67	2..6 ± 0.70

*C (control) = AB fertilizer, T1= AB fertilizer + FPJ

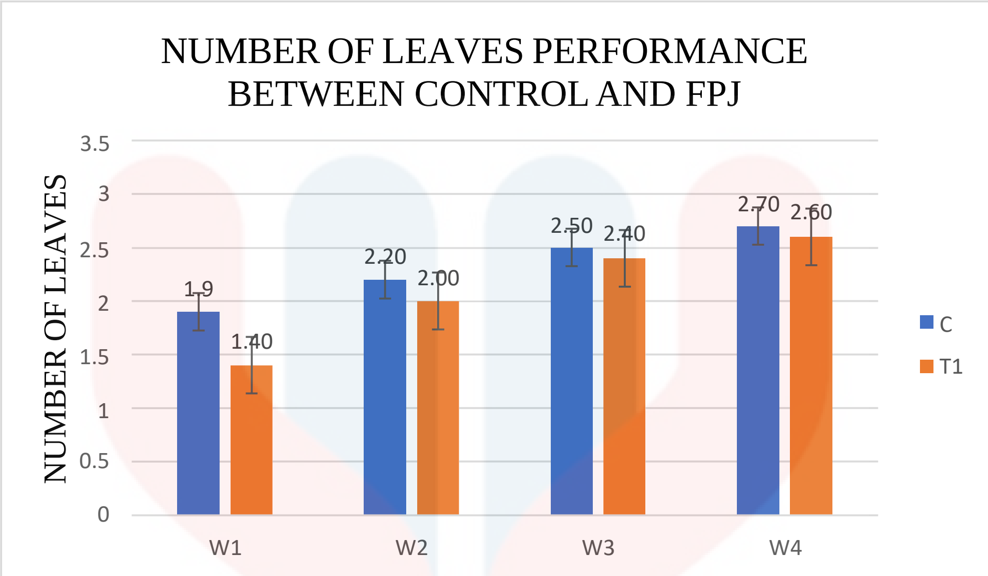

Figure 4.4: Graph shows the number of leaves performance between control and FPJ

The graph (Figure 4.5) shows the growth data of leaf number for control plants and treatment plants sprayed with FFJ at week 5 to week 8. Based on the graph, it can be seen that the leaf number for control and treatment is different. Where for control, in week 5 and week 6 the number of leaves has the same mean reading of 2.90 cm which does not show any increase during the period of 2 weeks. In the 7th week, the mean reading increased from 2.90 cm to 3.00 cm and the reading remained until week 8 which means no increase occurred during week 7 to week 8. For the number of leaves in FFJ treatment, it is increased from week 5 to week 8 with a mean reading of 2.60 cm to 3.10 cm. However, the leaf number was similar at weeks 6 and 7 with a mean reading of 2.80 cm.

Table 4.4: Growth performance of number of leaves between control and T2

WEEK	SAMPLE	
	C	T2(FFJ)
5	2.9 ± 0.88	2.6 ± 0.70
6	2.9 ± 1.20	2.8 ± 0.42
7	3.0 ± 1.49	2.8 ± 0.42
8	3.0 ± 1.63	3.1 ± 0.74

*C (control) = AB fertilizer, T1= AB fertilizer + FFJ

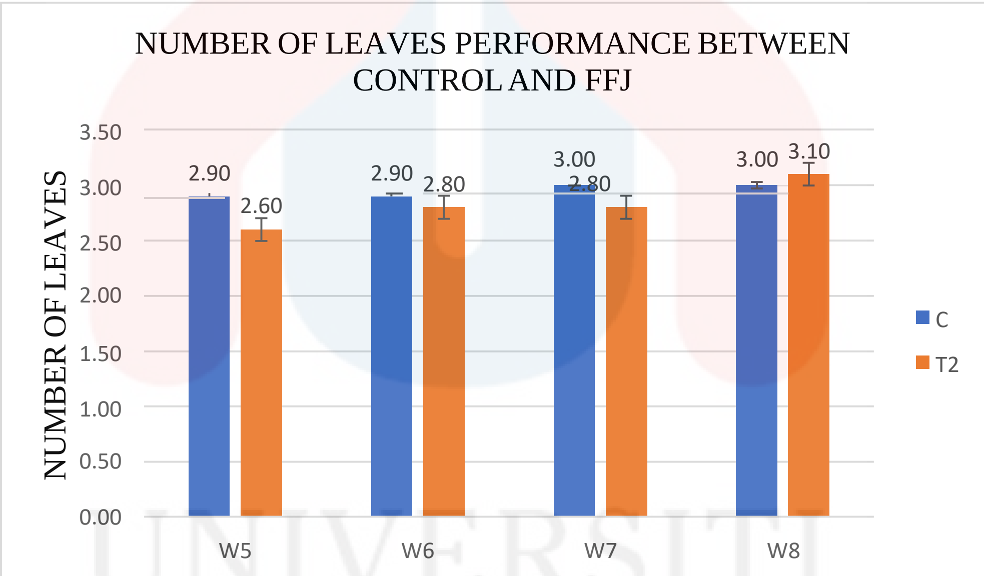

Figure 4.5: Graph shows the number of leaves performance between control and FFJ

Therefore, based on the two graphs, it can be seen that the number of leaves for control crops and treatment crops sprayed using FPJ and FFJ always increased during the week 8 of planting. However, the increase in leaf number for the control crop at week 1 to week 4 was high compared to the FPJ treated crop. Then, upon entering the 5th to 8th week, the number of leaves of the control plants was low compared to the treatment plants using FFJ. From these observations, it can be concluded that the use of FFJ plant supplement on black ginger plant is best for inducing leaf formation.

4.2.3 The Longest Leaves

The longest leaf growth for both control crops and treatment crops were also recorded over the 8 weeks of cultivation. In (Figure 4.6), the longest leaf growth for the control crop and FPJ treated crop showed an increase from week 1 to week 4. During the week, the mean reading of the control crop increased from 14.5 cm to 15.47 cm and the mean reading of the treated crop also increased from 14 .09 cm to 14.66 cm. Although both the control and treated plants increased their mean readings, it can be clearly seen that the control plants had the highest leaf length compared to the plants treated with FFJ.

Table 4.5: Average leaf length measured between control and T1

WEEK	SAMPLE	
	C	T1(FPJ)
1	14.5 ± 2.70	14.09 ± 2.80
2	14.58 ± 3.20	14.1 ± 2.65
3	14.99 ± 3.07	14.42 ± 2.54
4	15.47 ± 2.76	14.66 ± 2.76

*C (control) = AB fertilizer, T1= AB fertilizer + FPJ

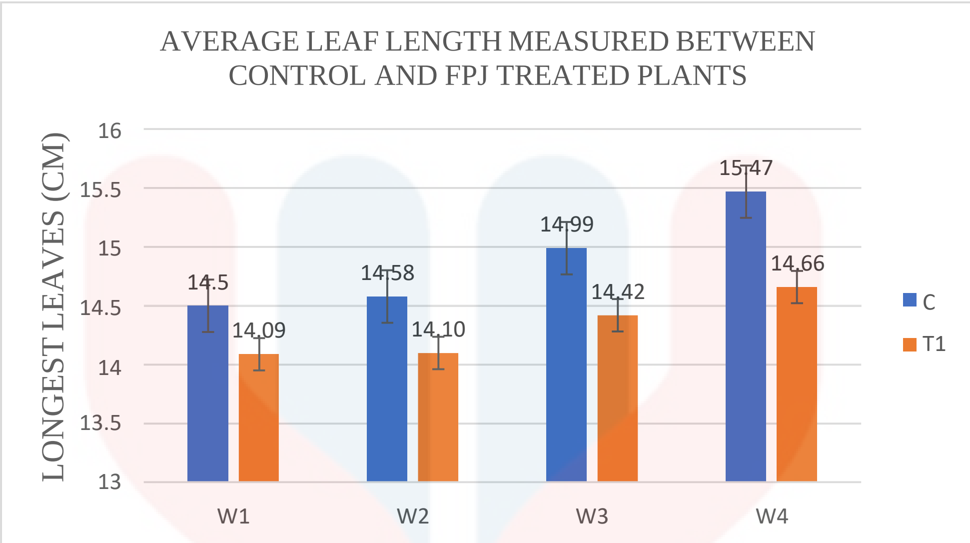

Figure 4.6: Average leaf length measured between control and FPJ treated plants

In Figure 4.7, it shows the longest leaf growth for control and treatment of FFJ in week 5 to week 8. From the graph it can be seen that the longest leaf for control crops decreased from a mean reading of 15.55 cm to 14.16 cm. Meanwhile, the mean reading for treatment crops sprayed with FFJ increased in week 5 to week 7 from a reading of 14.79 cm to 15.24 cm and again decreased in week 8 to a reading of 14.66 cm. However, it can be seen that FFJ treated plants have the highest leaf length compared to control plants.

Table 4.6: Average leaf length measured between control and T2

WEEK	SAMPLE	
	C	**T2(FFJ)**
5	15.55 ± 2.86	14.79 ± 2.89
6	15.12 ± 3.64	15.01 ± 3.51
7	15.07 ± 6.76	15.24 ± 4.32
8	14.16 ± 5.69	14.66 ± 3.08

*C (control) = AB fertilizer, T1= AB fertilizer + FFJ

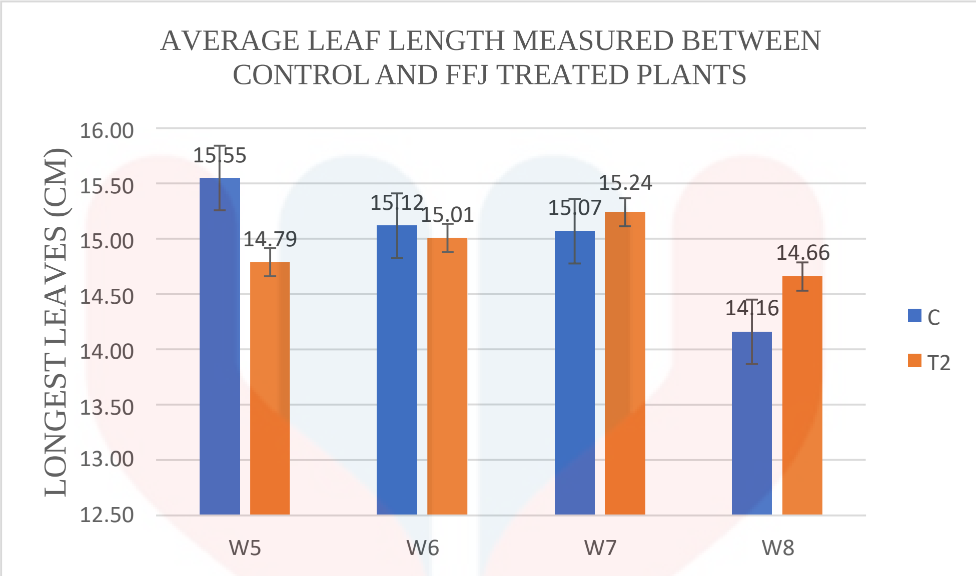

Figure 4.7: Average leaf length measured between Control and FFJ treated plants

Therefore, based on the two graphs it can be observed during the 8 weeks of planting, the longest leaf growth of the control crop increased in week 1 to week 4 and then decreased when entering the 5th week to week 8. Meanwhile, the treatment crop increased from week 1 to week 4 with FPJ plant supplementation until week 5 to week 7 with FFJ plant supplementation. However, at week 8 with FFJ administration the leaf length decreased. From this it can be ascertained that the use of FPJ and FFJ apart from AB fertilizer in the leaf length has a positive effect on black ginger crop.

4.2.4 The Widest Leaves

For the widest leaf data for control crops and treated crops using FPJ are shown in (Figure 4.8). From there, it can be seen that the widest leaf for control increased in week 1 to week 4 with the mean reading increasing from 7.94 cm to 8.32 cm and the mean reading for FPJ treatment plants also increased from 8.33 cm to 8.67 cm and this shows both crop samples have improvement. However, it can be seen there, the widest leaf for control crops is low compared to treatment crops using FPJ.

Table 4.7: Widest leaf mean measured between control and T1

WEEK	**SAMPLE**	
	C	**T1(FPJ)**
1	7.94 ± 1.11	8.33 ± 1.82
2	8.03 ± 1.10	8.66 ± 1.75
3	8.15 ± 1.00	8.71 ± 1.70
4	8.32 ± 0.94	8.67 ± 1.86

*C (control) = AB fertilizer, T1= AB fertilizer + FPJ

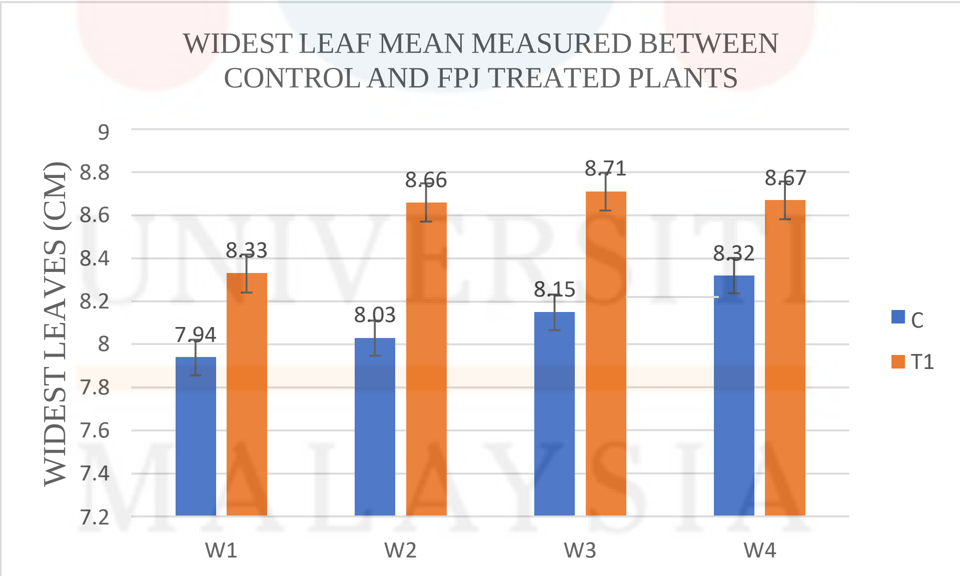

Figure 4.8: Widest leaf mean measured between control and FPJ treated plants

Then the widest leaf data for control crops and treatment crops using FFJ are shown in (Figure 4.9). From there it can be seen that the widest leaf for control decreased in week 5 to week 7 with a mean reading of 8.45 cm to 7.46 cm and then increased again in week 8 with a reading of 7.59 cm. As for the treatment crop, in the 5th and 6th week the mean reading decreased from 8.97 cm to 8.71 cm and then went up again in the 7th week with a reading of 8.90 cm and then decreased again in the 8th week with a reading of 8.83 cm. However, it can be clearly seen that the widest leaf growth for FFJ treatment plants is high compared to control crops.

Table 4.8: Widest leaf mean measured between control and T2

WEEK	SAMPLE	
	C	T2(FFJ)
5	8.45 ± 0.98	8.97 ± 1.87
6	8.13 ± 1.26	8.71 ± 1.97
7	7.46 ± 2.84	8.90 ± 2.05
8	7.59 ± 2.83	8.83 ± 2.15

*C (control) = AB fertilizer, T1= AB fertilizer + FFJ

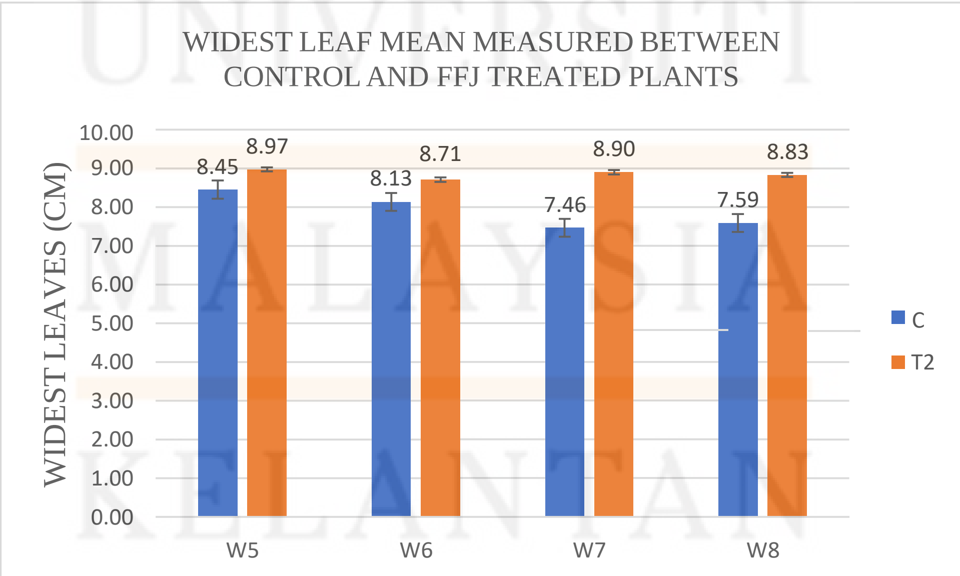

Figure 4.9: Widest leaf mean measured between control and FFJ treated plants

In relation to that, it can be stated here that the use of FPJ and FFJ as a plant supplement to the treatment crop sample is better than being supplied with AB fertilizer only. The decrease that occurred in both samples within 8 weeks of planting was probably due to excessive fertilizer application as well as weather factors that were too hot to cause the leaves to burn and be the cause of reduced leaf width of black ginger plant.

4.2.5 Weight of Young Rhizomes

The graph of the overall weight development of black ginger crops for the control and treatment samples is shown in (Figure 4.10). Based on the graph, the overall weight of the black ginger crop after 8 weeks of cultivation. Moreover, it can be seen that the mean reading for the overall weight of black ginger crop for the control sample was 28.42g and for the treated sample the mean reading was 31.15g. From the graph it can be clearly seen that the overall weight development of black ginger crop for control was low compared to treatment. This is due to the application of AB fertilizer only given to the control sample while the treatment sample in addition to being channeled with AB fertilizer it is also given additional plant supplements which were FPJ and FFJ. Through the graph it can be seen that the overall weight of black ginger plant for the both control and treated sample has a positive development, however, treated black ginger shows better weight increment compared to the control. The use of FPJ and FFJ can prove that its use as an additional supplement for plants is effective in helping the growth of black ginger plants better because there are additional nutrients from vegetables and fruits that can be used by plant material.

Table 4.9: Whole plant weight for sample control and treatment

SAMPLE	WEIGHT (KG)
Control (AB fertilizer)	28.42 ± 12.86
Treatment (AB fertilizer + FPJ & FFJ)	31.15 ± 19.00

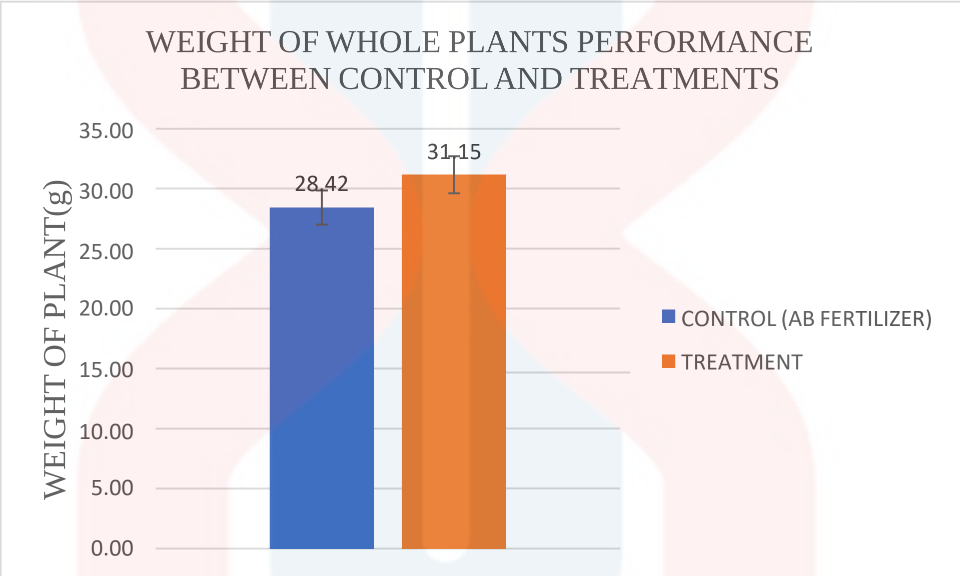

Figure 4.10: Graph shows the whole plant weight performance between control and treatment

4.3 Effect of Growth Performance on This Study

The graph shown in (Figure 4.11) is the effect of whole growth performance on control and treatment samples. In the graph it can be seen that the overall growth effect of crop height for the control and treatment samples is 27.14 cm and 25.15 cm. From here it can be seen the effect of height for the whole crop on the control sample is higher than that of the treatment sample. Further, for the overall growth effect on number of leaves could be seen in the control sample was higher than the treatment sample with mean readings of 2.64 cm and 2.46 cm. In addition, the effect of the longest overall leaf growth can also be seen in the readings for the control sample are higher than the treatment where the control sample with readings of 14.93 cm and treatment 14.62 cm. Then, for the effect of overall growth of the widest leaf, it can be seen that the mean reading of the control sample is lower with a reading of 8.01 cm compared to the treatment sample with a reading of 8.72 cm.

From the whole data it can be classified that the overall growth effect of the widest leaf showed that the treatment samples using FPJ and FFJ helped in leaf development although the height, number of leaves and leaf length showed otherwise. Through this graph it can be stated that the application of additional nutrients needs to be supplied to the crop to help its growth and produce high quality of yields.

Table 4.10: Effect of growth performance on sample control and treatment

PARAMETER	SAMPLE	
	CONTROL	**TREATMENT**
HEIGHT	27.14 ± 2.35	25.15 ± 1.00
NO. LEAVES	2.64 ± 0.35	2.46 ± 0.13
LONGEST LEAVES	14.93 ± 1.53	14.62 ± 0.59
WIDEST LEAVES	8.01 ± 0.83	8.72 ± 0.15

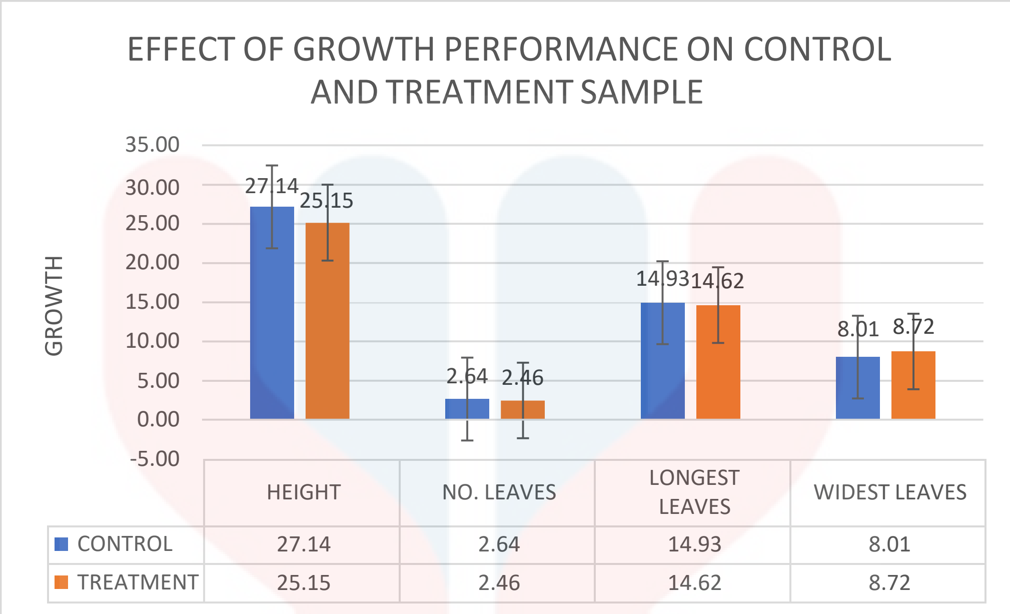

Figure 4.11: Graph shows the effect of growth performance on control and treatments

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The this study purpose is to observe the effect of fermented plant juice (FPJ) & fermented fruit juice (FFJ) on the growth performance of *Kaempferia parviflora* or black ginger cultivated using bench fertigation system. Based on the results of the study, it was found that the treated samples using AB and combination of FPJ and FFJ fertilizers as additional supplements had a good effect on the growth of black ginger compared to the control. The use of FPJ at week 1 to week 4 and FFJ at week 5 to week 8 has shown a positive effect on the parameters of height, number of leaves, and leaf length and leaf width of black ginger plants.

However, the use of FFJ is the most effective compared to FPJ and this is shown in (Figure 4.5) where the growth of the number of leaves increases when sprayed with FFJ. While for FPJ it is seen to be less effective on the leaf width parameter and this is shown in (Figure 4.8). Overall, with FPJ and FFJ application its affect the crop weight after 8 weeks which was higher than the control sample and this is shown in Figure 4.10.

Furthermore, the application of ginger cultivation by bench fertigation system has also shown good performance for the growth of black ginger crops. Through this method, land -related problems can be avoided while preserving the environment. This system simplifies crop management and reduces labor costs.

5.2 Recommendation

There are several suggestions based on this research project. First and foremost is in terms of cultivation of *Kaempferia parviflora* or black ginger. Black ginger cultivation can be grown using bench fertigation system such as stationary fertigation system, rolling fertigation system and many more as per the example mentioned by M.R. Evan., (2014). The improvement that is suggested based on this work is, other renewable component such as cultivation using new planting media such as from biochar sources. Then, in addition to using FPJ and FFJ as additional supplements for black ginger, other crop supplements can also be produced from other overripe fruits and withered vegetables as a new treatments on black ginger in order to help the better growth of ginger plants.

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APPENDICES A

1. Some of processes involved in growing black ginger plant

Figure A.1: *Kaempferia parviflora* or black ginger rhizome

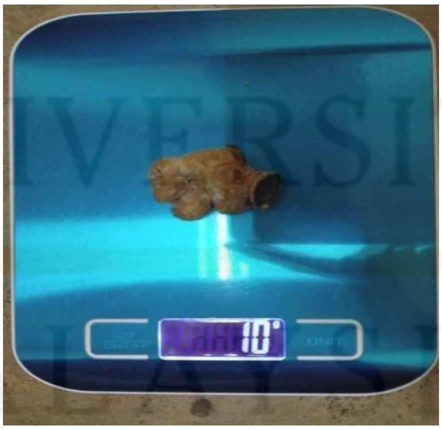

Figure A.2: Weighing cut rhizome

Figure A.3: Sowing rhizome

Figure A.4: Transplanting the plant seedling

Figure A.5: Growing the plant

2. Processes involve in making FPJ and FFJ

Figure B.1: Materials for making FPJ

Figure B.2: Materials for making FFJ

Figure B.3: Chopping all those material of FPJ and FFJ into tiny pieces

Figure B.4: In separate container, materials for FPJ and FFJ need to pour with molasses and mix it close the lid of containers.

Figure B.5: FPJ and FFJ fermented for a week

Figure B.6: Final product of FPJ and FFJ

APPENDICES B

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
PH1	0	10	25.3400	7.46789	2.36155	19.9978	30.6822	13.70	36.10
	1	10	24.2200	4.88599	1.54509	20.7248	27.7152	15.00	31.20
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	16.5200	12.88772	2.35297	11.7076	21.3324	.00	36.10
PH2	0	10	27.7300	5.29739	1.67518	23.9405	31.5195	20.50	36.00
	1	10	24.7200	4.69061	1.48330	21.3645	28.0755	15.50	32.20
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	17.4833	13.23642	2.41663	12.5408	22.4259	.00	36.00
PH3	0	10	27.9700	4.96768	1.57092	24.4163	31.5237	21.70	36.30
	1	10	24.9300	4.79399	1.51599	21.5006	28.3594	15.20	31.60
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	17.6333	13.31212	2.43045	12.6625	22.6042	.00	36.30
PH4	0	10	28.4400	4.60029	1.45474	25.1492	31.7308	22.90	36.50
	1	10	25.3800	5.54112	1.75226	21.4161	29.3439	14.50	31.50
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	17.9400	13.57136	2.47778	12.8724	23.0076	.00	36.50
PH5	0	10	28.4200	4.70173	1.48682	25.0566	31.7834	22.90	36.60
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	26.2800	7.11521	2.25003	21.1901	31.3699	14.40	39.20
	Total	30	18.2333	13.97573	2.55161	13.0147	23.4520	.00	39.20
PH6	0	10	28.1000	5.02394	1.58871	24.5061	31.6939	21.60	36.60
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	25.3700	6.38175	2.01809	20.8048	29.9352	14.00	34.00
	Total	30	17.8233	13.64075	2.49045	12.7298	22.9169	.00	36.60
PH7	0	10	25.6800	10.07724	3.18670	18.4712	32.8888	.00	36.80
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	24.2500	5.72950	1.81183	20.1514	28.3486	13.50	30.00
	Total	30	16.6433	13.61368	2.48551	11.5599	21.7268	.00	36.80
PH8	0	10	25.4700	9.96851	3.15232	18.3390	32.6010	.00	36.50
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	25.1800	7.23015	2.28638	20.0079	30.3521	13.70	38.50
	Total	30	16.8833	13.94687	2.54634	11.6755	22.0912	.00	38.50

Figure B.1: Mean and standard deviation for plant height

NOL1	0	10	1.90	.738	.233	1.37	2.43	1	3
	1	10	1.40	.516	.163	1.03	1.77	1	2
	2	10	.00	.000	.000	.00	.00	0	0
	Total	30	1.10	.960	.175	.74	1.46	0	3
NOL2	0	10	2.20	.919	.291	1.54	2.86	1	3
	1	10	2.00	.667	.211	1.52	2.48	1	3
	2	10	.00	.000	.000	.00	.00	0	0
	Total	30	1.40	1.192	.218	.95	1.85	0	3
NOL3	0	10	2.50	.850	.269	1.89	3.11	1	4
	1	10	2.40	.699	.221	1.90	2.90	1	3
	2	10	.00	.000	.000	.00	.00	0	0
	Total	30	1.63	1.326	.242	1.14	2.13	0	4
NOL4	0	10	2.70	.675	.213	2.22	3.18	2	4
	1	10	2.60	.699	.221	2.10	3.10	1	3
	2	10	.00	.000	.000	.00	.00	0	0
	Total	30	1.77	1.382	.252	1.25	2.28	0	4
NOL5	0	10	2.90	.876	.277	2.27	3.53	2	4
	1	10	.00	.000	.000	.00	.00	0	0
	2	10	2.60	.699	.221	2.10	3.10	1	3
	Total	30	1.83	1.464	.267	1.29	2.38	0	4
NOL6	0	10	2.90	1.197	.379	2.04	3.76	1	5
	1	10	.00	.000	.000	.00	.00	0	0
	2	10	2.80	.422	.133	2.50	3.10	2	3
	Total	30	1.90	1.539	.281	1.33	2.47	0	5
NOL7	0	10	3.00	1.491	.471	1.93	4.07	0	5
	1	10	.00	.000	.000	.00	.00	0	0
	2	10	2.80	.422	.133	2.50	3.10	2	3
	Total	30	1.93	1.639	.299	1.32	2.55	0	5
NOL8	0	10	3.00	1.633	.516	1.83	4.17	0	5
	1	10	.00	.000	.000	.00	.00	0	0
	2	10	3.10	.738	.233	2.57	3.63	2	4
	Total	30	2.03	1.771	.323	1.37	2.69	0	5

Figure B.2: Mean and standard deviation for number of leaves

LL1	0	10	14.5000	2.69774	.85310	12.5702	16.4298	11.00	19.00
	1	10	14.0900	2.80256	.88625	12.0852	16.0948	10.10	19.30
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	9.5300	7.19037	1.31278	6.8451	12.2149	.00	19.30
LL2	0	10	14.5800	3.20340	1.01300	12.2884	16.8716	10.70	21.00
	1	10	14.1000	2.65204	.83865	12.2028	15.9972	9.50	18.50
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	9.5600	7.25808	1.32514	6.8498	12.2702	.00	21.00
LL3	0	10	14.9900	3.06502	.96924	12.7974	17.1826	11.00	21.50
	1	10	14.4200	2.54025	.80330	12.6028	16.2372	9.50	18.40
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	9.8033	7.39485	1.35011	7.0421	12.5646	.00	21.50
LL4	0	10	15.4700	2.76045	.87293	13.4953	17.4447	12.30	21.70
	1	10	14.6600	2.76092	.87308	12.6850	16.6350	9.50	18.20
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	10.0433	7.55096	1.37861	7.2238	12.8629	.00	21.70
LL5	0	10	15.5500	2.85861	.90397	13.5051	17.5949	12.30	22.00
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	14.7900	2.88731	.91305	12.7245	16.8555	9.90	18.70
	Total	30	10.1133	7.62404	1.39195	7.2665	12.9602	.00	22.00
LL6	0	10	15.1200	3.63831	1.15054	12.5173	17.7227	8.40	22.00
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	15.0100	3.51139	1.11040	12.4981	17.5219	9.00	20.80
	Total	30	10.0433	7.75307	1.41551	7.1483	12.9384	.00	22.00
LL7	0	10	15.0700	6.76364	2.13885	10.2316	19.9084	.00	25.70
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	15.2400	4.31926	1.36587	12.1502	18.3298	9.60	24.00
	Total	30	10.1033	8.53175	1.55768	6.9175	13.2891	.00	25.70
LL8	0	10	14.1600	5.69019	1.79939	10.0895	18.2305	.00	22.50
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	14.6600	3.07759	.97322	12.4584	16.8616	9.50	18.40
	Total	30	9.6067	7.79527	1.42321	6.6959	12.5175	.00	22.50

Figure B.3: Mean and standard deviation for longest leaves

WL1	0	10	7.9400	1.11375	.35220	7.1433	8.7367	6.20	10.00
	1	10	8.3300	1.82455	.57697	7.0248	9.6352	5.40	11.10
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	5.4233	4.08139	.74516	3.8993	6.9473	.00	11.10
WL2	0	10	8.0300	1.10056	.34803	7.2427	8.8173	6.10	10.10
	1	10	8.6600	1.74941	.55321	7.4085	9.9115	5.30	11.10
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	5.5633	4.17170	.76164	4.0056	7.1211	.00	11.10
WL3	0	10	8.1500	.99805	.31561	7.4360	8.8640	6.60	10.00
	1	10	8.7100	1.69997	.53758	7.4939	9.9261	5.50	11.20
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	5.6200	4.19486	.76587	4.0536	7.1864	.00	11.20
WL4	0	10	8.3200	.94021	.29732	7.6474	8.9926	7.00	10.20
	1	10	8.6700	1.85775	.58747	7.3410	9.9990	5.50	11.40
	2	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	30	5.6633	4.23748	.77365	4.0810	7.2456	.00	11.40
WL5	0	10	8.4500	.97781	.30921	7.7505	9.1495	7.10	10.40
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	8.9700	1.87205	.59199	7.6308	10.3092	5.70	11.50
	Total	30	5.8067	4.34408	.79312	4.1846	7.4288	.00	11.50
WL6	0	10	8.1300	1.26144	.39890	7.2276	9.0324	6.30	10.50
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	8.8800	1.93149	.61079	7.4983	10.2617	5.60	11.30
	Total	30	5.6700	4.28688	.78267	4.0693	7.2707	.00	11.30
WL7	0	10	7.4600	2.84339	.89916	5.4260	9.4940	.00	10.40
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	8.9000	2.04831	.64773	7.4347	10.3653	5.50	11.70
	Total	30	5.4533	4.42163	.80728	3.8023	7.1044	.00	11.70
WL8	0	10	7.5900	2.83174	.89548	5.5643	9.6157	.00	10.40
	1	10	.0000	.00000	.00000	.0000	.0000	.00	.00
	2	10	8.8300	2.15203	.68053	7.2905	10.3695	5.70	11.50
	Total	30	5.4733	4.43691	.81007	3.8166	7.1301	.00	11.50

Figure B.4: Mean and standard deviation for widest leaves

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
PH1	Between Groups	4099.928	2	2049.964	77.219	.000
	Within Groups	716.780	27	26.547		
	Total	4816.708	29			
PH2	Between Groups	4630.305	2	2315.152	138.731	.000
	Within Groups	450.577	27	16.688		
	Total	5080.882	29			
PH3	Between Groups	4710.225	2	2355.112	148.244	.000
	Within Groups	428.942	27	15.887		
	Total	5139.167	29			
PH4	Between Groups	4874.472	2	2437.236	140.971	.000
	Within Groups	466.800	27	17.289		
	Total	5341.272	29			
PH5	Between Groups	5009.715	2	2504.857	103.318	.000
	Within Groups	654.592	27	24.244		
	Total	5664.307	29			
PH6	Between Groups	4802.333	2	2401.166	109.199	.000
	Within Groups	593.701	27	21.989		
	Total	5396.034	29			
PH7	Between Groups	4165.233	2	2082.616	46.495	.000
	Within Groups	1209.401	27	44.793		
	Total	5374.634	29			
PH8	Between Groups	4276.125	2	2138.062	42.297	.000
	Within Groups	1364.817	27	50.549		
	Total	5640.942	29			

Figure B.5: ANOVA of plant height

NOL1	Between Groups	19.400	2	9.700	35.877	.000
	Within Groups	7.300	27	.270		
	Total	26.700	29			
NOL2	Between Groups	29.600	2	14.800	34.448	.000
	Within Groups	11.600	27	.430		
	Total	41.200	29			
NOL3	Between Groups	40.067	2	20.033	49.624	.000
	Within Groups	10.900	27	.404		
	Total	50.967	29			
NOL4	Between Groups	46.867	2	23.433	74.435	.000
	Within Groups	8.500	27	.315		
	Total	55.367	29			
NOL5	Between Groups	50.867	2	25.433	60.770	.000
	Within Groups	11.300	27	.419		
	Total	62.167	29			
NOL6	Between Groups	54.200	2	27.100	50.462	.000
	Within Groups	14.500	27	.537		
	Total	68.700	29			
NOL7	Between Groups	56.267	2	28.133	35.167	.000
	Within Groups	21.600	27	.800		
	Total	77.867	29			
NOL8	Between Groups	62.067	2	31.033	28.993	.000
	Within Groups	28.900	27	1.070		
	Total	90.967	29			

Figure B.6: ANOVA for number of leaves

LL1	Between Groups	1363.154	2	681.577	135.125	.000
	Within Groups	136.189	27	5.044		
	Total	1499.343	29			
LL2	Between Groups	1372.056	2	686.028	118.998	.000
	Within Groups	155.656	27	5.765		
	Total	1527.712	29			
LL3	Between Groups	1443.205	2	721.602	136.605	.000
	Within Groups	142.625	27	5.282		
	Total	1585.830	29			
LL4	Between Groups	1516.309	2	758.154	149.216	.000
	Within Groups	137.185	27	5.081		
	Total	1653.494	29			
LL5	Between Groups	1537.081	2	768.540	139.665	.000
	Within Groups	148.574	27	5.503		
	Total	1685.655	29			
LL6	Between Groups	1513.089	2	756.544	88.771	.000
	Within Groups	230.105	27	8.522		
	Total	1743.194	29			
LL7	Between Groups	1531.305	2	765.652	35.665	.000
	Within Groups	579.625	27	21.468		
	Total	2110.930	29			
LL8	Between Groups	1385.571	2	692.785	49.662	.000
	Within Groups	376.648	27	13.950		
	Total	1762.219	29			

Figure B.7: ANOVA of longest leaves

WL1	Between Groups	441.949	2	220.974	145.077	.000
	Within Groups	41.125	27	1.523		
	Total	483.074	29			
WL2	Between Groups	466.245	2	233.122	163.722	.000
	Within Groups	38.445	27	1.424		
	Total	504.690	29			
WL3	Between Groups	475.334	2	237.667	183.479	.000
	Within Groups	34.974	27	1.295		
	Total	510.308	29			
WL4	Between Groups	481.713	2	240.856	166.674	.000
	Within Groups	39.017	27	1.445		
	Total	520.730	29			
WL5	Between Groups	507.113	2	253.556	170.528	.000
	Within Groups	40.146	27	1.487		
	Total	547.259	29			
WL6	Between Groups	485.046	2	242.523	136.713	.000
	Within Groups	47.897	27	1.774		
	Total	532.943	29			
WL7	Between Groups	456.451	2	228.225	55.753	.000
	Within Groups	110.524	27	4.093		
	Total	566.975	29			
WL8	Between Groups	457.049	2	228.524	54.195	.000
	Within Groups	113.850	27	4.217		
	Total	570.899	29			

Figure B.8: ANOVA of widest leaves

ANOVA

PW

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	37.265	1	37.265	.142	.711
Within Groups	4738.535	18	263.252		
Total	4775.799	19			

Figure B.9: ANOVA of plant weight