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Comparative Effect on Application of Crustacean Foliar and Commercial Fertilizer on Maize (*Zea Mays*) Growth Performance

By

Malissa Shamimi Binti Hassan

A report submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (Animal Husbandry Science) with Honours

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DECLARATION

I hereby declare that the work embodied in this report is the result of the original research and has not been submitted for a higher degree to any universities or institutions.

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Student

Name: Malissa Shamimi Binti Hassan

Date:

I certify that the report of this final year project entitled Comparative effect on application of crustacean foliar and commercial fertilizer on Maize (*Zea Mays*) growth performance by Malissa Shamimi Binti Hassan, matric number F14A0128 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Animal Husbandry Science) with Honours, Faculty of Agro-Based Industry, University Malaysia Kelantan.

Approved by:

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Supervisor

Name: Miss Hazreen Nita Binti Mohd Khalid

Date:

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Comparative Effect on Application of Crustacean Foliar and Commercial Fertilizer on Maize (*Zea Mays*) Growth Performance

ABSTRACT

Fertilizer usage were commonly practiced among farmers in order to grow their agricultural crops. However, there were abundance usage of commercial fertilizer that give impacts to plants. In this study, crustacean foliar and commercial fertilizer were used to compare their effectiveness on maize growth performance. Materials used for crustacean foliar preparation were mostly from agricultural wastes such as shrimp wastes including head, tail, shells, and pumpkin fruits waste such as peels, with an addition of molasses. This crustacean foliar was fermented for two months prior for application. A total of 30 Maize plants were divided into two groups which represented as control that used commercial fertilizer, and as treatment that used crustacean foliar. The application of these fertilizers were done twice a week through spraying on stomata of leaf respectively. Growth performance of maize plants were recorded based on plant height, number of leaf, wide and length of leaf twice a week for two months of planting period. The findings showed commercial fertilizer gave better plant growth performance compared to crustacean foliar treatment where towards the end of planting period, control plants had reached 34.01 ± 5.01 cm height while plants applied with crustacean foliar only reached 18.00 ± 4.77 cm height. In addition, statistically the data showed significance difference ($p<0.05$) between both groups. In conclusion, the commercial fertilizer had better efficiency than crustacean foliar towards growth performance of Maize plants. Further improvement need to be done to improve the quality of crustacean foliar which were lacking of major nutrients in order to produce an alternative organic fertilizer.

Keywords: fertilizer, growth performance, Maize plants, fermentation, plants height

Perbezaan Kesan Penggunaan Baja Cecair Udang dan Baja Komersial Terhadap Prestasi Pertumbuhan Jagung (*Zea Mays*)

ABSTRAK

Penggunaan baja kebiasaannya digunakan oleh petani untuk tanaman agrikultur mereka. Walau bagaimanapun, terdapat banyak penggunaan baja komersial yang memberi kesan kepada tumbuhan. Dalam kajian ini, baja cecair udang dan baja komersial telah digunakan untuk membandingkan keberkesanannya terhadap prestasi pertumbuhan pokok jagung. Bahan-bahan untuk penyediaan baja cecair udang kebanyakannya daripada sisa agrikultur seperti sisa udang termasuk kepala, ekor, kulit dan sisa daripada buah labu iaitu kulit dengan penambahan molases. Baja cecair udang telah mengambil masa selama 2 bulan fermentasi sebelum penggunaan. Sebanyak 30 pokok jagung telah dibahagikan kepada 2 kumpulan iaitu kumpulan kawalan yang menggunakan baja komersial dan kumpulan rawatan yang menggunakan baja cecair udang. Penggunaan baja-baja ini telah dilakukan dalam 2 kali seminggu melalui semburan pada stomata daun. Prestasi pertumbuhan pokok jagung berdasarkan ketinggian pokok, bilangan helaian daun, lebar dan panjang daun telah direkodkan dalam 2 kali seminggu untuk 2 bulan tempoh penanaman. Hasil kajian telah menunjukkan baja komersial memberi kesan lebih baik pada prestasi pertumbuhan pokok berbanding rawatan baja cecair udang di mana pada akhir tempoh penanaman, pokok kawalan telah mencapai ketinggian 34.01 ± 5.01 cm manakala pokok rawatan hanya mencapai ketinggian 18.00 ± 4.77 cm. Tambahan pula, secara statistiknya data menunjukkan perbezaan bererti ($P<0.05$) antara kedua-dua kumpulan. Konklusinya, baja komersial mempunyai kecekapan yang lebih baik berbanding baja cecair udang terhadap prestasi pertumbuhan pokok jagung. Penambahbaikan perlu dilakukan pada masa hadapan untuk menambahbaik kualiti baja cecair udang yang mempunyai kekurangan nutrien utama dalam menghasilkan baja organik alternatif.

Kata kunci: baja, prestasi pertumbuhan, pokok jagung, fermentasi, ketinggian pokok

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LIST OF ABBREVIATIONS AND SYMBOLS

pH	Acidity
kg	Kilogram
ATP	Adenosine triphosphate
RCBD	Randomized Complete Block Design
L	Litre
mL	Millilitre
m	Meters
XRF	X-ray Fluorescence
MARDI	Malaysia Agricultural Research and Development Institute
%	Percent
H_2O	Water
N	Nitrogen
P	Phosphorus
K	Potassium
cm	Centimetre
N	Number of replication
SEM	Standard Error of Mean
n	Number of leaves
<	Less than
±	Plus minus

CHAPTER 1

INTRODUCTION

1.1 Background of study

Chitosan is a compound derived from protein that available in all skeleton of insects, crustaceans and fungi. According to Salachna and Zawadzińska (2014), chitosan is classified as special characteristics in terms of bioactivity and bio-compatibility. Chitosan can improve the yield, lower in transpiration and also encouraged to change the metabolic where plants become unsusceptible to microbes infection. Chitin is polysaccharide that available on exoskeleton of crustaceans such as shrimps, lobsters, bivalves, crabs and many more. It also can be found in insects, arachnids, microorganism such as fungi and spine of diatoms available in cell wall, membrane and spores.

Chitosan fertilizer has been practiced long time ago by farmers in other countries. However, only few farmers had used this fertilizer for their crops in Malaysia. Chitosan fertilizers are fertilizers produced using by-products of crustacean such as shells crabs, shrimps and bivalve. The chitin or chitosan from the shells would be benefits to the crops as it can slowly release nitrogen to the soil and enhance strong stalk and green leaves for plants. The chitin itself may induce growth of bacterial that eat the chitin from insects, nematodes and fungal which these parasites of soil have their own chitin as well.

Fertilization helps to increase efficiency and gain better quality of product in agricultural activities. Non-organic fertilizers primarily consist of phosphate, nitrate, ammonium and potassium salts. Fertilizer industry is a source of natural radionuclides such as ^{238}U, ^{232}Th and ^{210}Po and heavy metals such as Hg, Cd, As, Pb, Cu, Ni and Cu as a potential source. In spite of that, the utilization of fertilizer which had rapidly increase across the world may lead to serious environmental problems. Basically, plants will take up the fertilizers in the soil which they can enter the food chain. Hence, fertilization may pollute the water, soil and air. Fertilization may affect the collection of heavy metals in soil and plant system. The extreme use of chemical fertilizers on crop plantation may cause large number of environmental problems because some fertilizers may consist heavy metals such as chromium and cadmium and also have high concentrations of radionuclides (Savci, 2012).

1.2 Problem statement

Excessive usage of fertilizer and manure applications in agriculture industry in Malaysia lead to environment pollution. The Government has promote the sustainable agriculture and organic farming as a way to get rid of the unsustainable agriculture but people are still did not aware about the organic farming especially farmers. Previous study had conducted a survey in Cameron Highland to highlight the challenges or issues that faced by farmers regarding to this practice of organic farming. The results were mainly about land issue, lack of financial support from Government, less labour, lack of training on organic farming, marketing issue regarding to less awareness by people about health benefits of consuming organic products and certification process (Tiraieyari, Hamzah, & Samah, 2014).

Organic farming should be applied in Malaysia. Government should give awareness to the farmers about the benefits of organic farming. Organic farming is one of ecological process that applied on agricultural production system that should provide enough food for the higher number of population (Tiraieyari et al., 2014). Organic farming is related to usage of natural fertilizers such as compost or manure for soil and plants. This method will minimize the usage of chemical fertilizers to produce crops that are non-toxic and thus lead to less environmental pollution occur. The organic farming is an ecological agriculture that depend on ecosystem management. It can help for sustaining in socio-economic in developing countries. For example, organic farming can assist development of rural to involve in tourism activities, provide employment and generate income especially in poor countries (Tiraieyari et al., 2014).

1.3 Objectives of study

1. To determine the growth performance of Maize plants by application of crustacean foliar and commercial fertilizer.
2. To compare the effectiveness between crustacean foliar and commercial fertilizer application towards Maize crop production.

1.4 Hypothesis

H_0 : The crustacean foliar will not enhance the growth performance of Maize plants compared to commercial fertilizer

H_a : The crustacean foliar will enhance the growth performance of Maize plants compared to commercial fertilizer

If p value less than 0.05, H_0 was accepted.

If p value greater than 0.05, H_A was rejected.

1.5 Scope of study

This study was focused on by-products development. The crustacean wastes used as main ingredient in producing organic fertilizers. The effect of this potential organic fertilizer was tested on Maize plants growth performance in comparison with chemical fertilizer as control group.

1.6 Significance of study

The study was carried out to reveal the solution to overcome the abundance of waste such as crustacean shells that have been disposed by industry. In order to reduce the wastes that are accumulated, proper waste management can be practiced by converting them into potential valuable by-products such as organic fertilizers. In addition, the usage of organic fertilizer to crops can prevent harmful disease which minimize mortality of plants and reduce health risk of animals and people that consumed plants. Thus, utilization of organic fertilizer may be the best option to overcome this environmental issues as well as providing better plant growth performance as an alternative to chemical fertilizer.

CHAPTER 2

LITERATURE REVIEW

2.1 Fertilizer

Agriculture industry in Malaysia consists of two different sectors which are plantation sectors and the smallholder sector. The major crops planting are include oil palm, rice, rubber, coconut, orchard and mixed horticulture. The excessive usage of chemical fertilizer by farmers to gain yield production is the results of reliance on these primary commodities in the industry. According to Ahmad (2001), the development of primary commodities lead to large quantities of importation of manufactured chemical fertilizers which buy about 14.5 million tons and RM 1.32 billion value in annually. In recent years, as a result of many concerns related to health risk from the chemical fertilizer application, there is an attempt to review the usage of these fertilizers while stressing the introduction of organic fertilizers. A positive effect of organic fertilizer usage can be observed when the organic waste and by products from the animal are recycle for productive use as well as less of waste disposal and burning of waste products that lead to both soil, water and air pollution.

Fertilizers are chemical compound which applied on crop production to improve the growth of plants and fruits development. Fertilizers are usually applied either on soil for plant roots uptake or by foliar feeding for leaves uptake. Other than that, fertilizer can be applied on aquaculture systems particularly ocean fertilization. Human food sources are depending on animals and plants production. With the rapid increase of human population in global, the demands of food and agricultural yield will be rapidly increasing too. Farmers need fertilizers to be added on the soil in order to supply the crucial nutrients and enhance the growth of crops in the soil. However, they are used chemical fertilizers that are available in the market instead of using organic fertilizer.

Chemical fertilizer is an artificial manufactured that provide main nutrients such as nitrogen, phosphorus and potassium in specific quantities. Acidity of chemical fertilizer would give bad effects on soil in terms of structure, health and pH for long term use. Nitrogen involve in chlorophyll synthesis and proteins for leaf growth. Both phosphorus and potassium involve in development of flower and root and however, potassium also involve in protein synthesis (Corradini, de Moura, & Mattoso, 2010).

According to Agricultural and Rural Development of Alberta, Canada, farmers tend to use chemical fertilizers because it has special formulated nutrient for plants and require lesser time for nutrient absorption (agric.gov.ab.ca, 2004). Meaning that, these tiny nutrients will readily dissolve into the soil and directly take up by the plants unlike organic fertilizer, all of nutrients must be degraded in the soil before plants can take up the nutrients. The farmers should use organic fertilizer as it may benefits for soil fertility, lower cost and safe to environment.

Generally, vegetables contain sources of vitamin, fats, carbohydrate, proteins, minerals and calories that benefits for people consumption. However, vegetable residues often disposed by people and becoming wastes such as peels, seeds and leaves. Previous study was conducted in Brazil to determine the proximal composition of minerals in fruit peels and seeds reported that higher content nutrients in peels and seed compared to pulp (Carolina, Staichok, Rayssa, Mendonça, & Guerra, 2016).

Pumpkins have large amount of vitamin A, vitamin B, calcium, carbohydrate and phosphorus. Other than that, pumpkin peels do not have carbohydrates, lipids, iron and potassium but this non-edible parts of vegetables do have significant amount of proteins, fiber, calcium and ascorbic acid.

2.2 Crustacean by-product

Aquaculture is a food production sector that are growing faster in the world. Asia plays major role in aquaculture sector which represent almost 80% of world shrimp productions (Sachindra, Bhaskar, & Mahendrakar, 2006). Shrimp is one of crucial aquaculture products in worldwide including Bangladesh. The product is exported in frozen environment where shrimp head and skin were separate. The crude shrimp head and skin were being treated as bio-waste or sold to animal feed manufactures due to low economic value. A large amount of shrimp bio-waste are generated through processing in shrimp industries which estimated about 45%-55% of the shrimp weight. However, the bio-waste can be used to produce chitosan (Hossain & Iqbal, 2014).

The main source of value added products such as chitin and chitosan can be obtained from crustacean waste (Jagadeeswari, Dakshinamoorthy, & Padmanabhan, 2012). Chitin is a natural polysaccharide that was first identified in 1884 (Younes & Rinaudo, 2015). After cellulose, chitin is the second great natural biopolymer that found in nature. In nature, chitin form as crystalline micro fibrils that form as structural component in exoskeleton of arthropods shells as well as fungi and yeast cell walls. It is also occurred in other living organisms at bottom of the plant and other animals which have many functions. Even though there are many sources of chitin, the commercial chitin sources come from crab and shrimp shells (Rinaudo, 2006). The estimation annually worldwide production of crustacean shells is about 1.2 x 10^6 tons. The recovery of chitin and proteins can be additional source of revenue. However, crustacean shell wastes can be limited supply during season. In few years ago, it become important where chitin can be extracted from fungal mycelia.

Chitosan is a derivative of chitin which has been found in crustaceans, insects, fungi and some algae. In general, the shell of selected crustacean have 30%-40% protein, 30%-50% calcium carbonate and calcium phosphate and 20%-30% chitin. Similarly with cellulose, chitosan is non-toxic, biodegradable biopolymer with high molecular weight. The only difference between these two molecules is structure of amine ($-NH_2$) group in the position C-2 chitosan while cellulose, a plant fiber has hydroxyl (-OH) group in the position of C-2. Chitosan also has positive charge that bind with negative charge fats, cholesterol, lipids, proteins, metal ions and macromolecules. Besides, chitin and chitosan also have benefits in biocompatibility, biodegradability, films forming ability, absorption and to chelate metal ions (Hossain & Iqbal, 2014).

Chitin is used as a raw material to produce its derived products such as chitosan, oligosaccharides and glucosamine hydrochloride. The estimation of worldwide production of these derivatives have been reported in 2001 where the production was more than 10,000 tons (Pal et al., 2014). Instead of agriculture, chitin and chitosan can be applied in other fields such as biomedical and biotechnology fields. In biomedical, these materials are use as wound healing and dressings, drug delivery agents, anti-cholesterolemic agents, anti-coagulants of blood, anti-tumor agents and immunoadjuvant. In biotechnology, the materials involve in applications such as manufacture of textile, paper, film and sponge sheet materials, wastewater treatment where chitin acts as an absorbent for heavy and radioactive metals as well as feed additives. Chitosan have also importance in food applications such as purification of drinking water, recovering protein from meat processing plants and fish wash water, in animal feeds and clarifying wine.

The waste of Northern shrimp (*Pandalus borealis*) that contain high quality of chitosan is applied in cosmetics (Gildberg & Stenberg, 2001). In Norway, the commercial production of chitosan from shrimp waste is already established that produce high quality of cosmetics and hair conditioning products. The processing of chitosan from shrimp waste required extraction of both minerals and tissue proteins from shrimp waste and resulted about 10% of raw material dry matter which is chitosan. Approximately, 3 kg of protein was wasted for each kilogram of chitosan produced. Protein tissue in shrimp waste can be hydrolysed and can treated with Alcalasae which is commercial available protease preparation.

According to Pal et al. (2014), chitosan is used in thin layer chromatography to separate nucleic acid. In animal nutrition, the utilization of whey was improved by adding small amount of chitin in the diet as it change the intestinal flora of the animal. Chitosan also has various applications in agricultural field where chitosan solution may acts as the bacteriostatic agent and haemostatic agent (Pal et al., 2014). Chitosan derivatives also act as emulsifiers, antistatic agents and emollients, nail polishes and tooth pastes.

The source of chitin is from crustacean shells become waste from marine processing food products. The production of crustacean shells in worldwide is estimated about 1.2 x 10^6 tons annually. The chitin and proteins can be additional source of revenue. However, crustacean shell wastes can be limited. In few years ago, it become important where chitin can be extracted from fungal mycelia.

Nowadays, there are new practices in agriculture field are being expanded for varieties of crops and vegetables. In India, there are many researches related to chitosan association on different plants growth. Chitosan and its oligosaccharides are natural molecule that are used to crops for reducing the cost and kill the chemical bactericides. By having low cost inputs and high potential for increased the supply, farmers could obtain the benefits from these application of chitosan and oligosaccharides to crops (Katiyar, Hemantaranjan, Singh, & Bhanu, 2014).

2.3 Application of Chitosan on Maize crops

2.3.1 Maize crop

The main nutrient elements for Maize growth are nitrogen, phosphorus and potassium. These elements are derived from soil or fertilizer compounds that contain ammonia (NH^{4+}), nitrate (NO^{3-}) ions and phosphate (PO^{4-}) ions and salts containing potassium. Nitrogen is the main element to produce high quality of corn. It is absorbed by Maize plants and involved in plant growth throughout Maize cultivation period. It also contributed to the protein content increase in grain and stover, number and size of ear Maize plants and green colour development of leaf. Maize production yield may increase of nitrogen in high levels of nitrogen fertilizer application. From previous study, sweet corn production in Hawaii was increased with higher application of nitrogen to 200lb/acre (Brewbaker, 2003). Approximately, 60% of nitrogen is needed and absorbed by plants during time of pollination until achieved maturity phase.

There are two roles of phosphorus in growth performance of plants such as building blocks for cellular compound and energy ATP transfer in fuel cellular process. Phosphorus is taken up mostly during young stage which is young tissues that contain high metabolic activity where the root system is too small to forage for soil. Mycorrhizal soil fungi helped to colonize the root and elongated the root system in order to absorb phosphorus by the roots. Approximately, half of the total phosphorus of mature maize plants is in grain. Higher application of phosphorus fertilizer is needed on soils in the beginning of maize production which have strong ability to bind phosphorus. In addition, potassium is an element that uptake by Maize plants in higher amount mostly during early growth of Maize plants. Approximately, 80% of nutrient K uptake during pollination period.

Secondary nutrients different from N, P and K which needed in Maize crop but in certain soil. For example, the growing tissues of corn contain 0.4% Ca whereas the seeds contain less than 0.01%. Calcium is important for plant cell walls formation and neutralize the cellular acids. Other than that, magnesium contributed to chlorophyll formation and about 0.3% magnesium of the weight of a Maize plant. The production of Maize in Nepal has become the second position of the most important crop after rice whereas in South Africa, the most important crop is the maize plant (du Plessis, 2003; Govind, Karki, Shrestha, & Achhami, 2015). The production of Maize plants will be success if the application of production inputs is appropriate that will sustain the environment and agricultural production. These inputs such as soil horticulture, plant population, insect, weed, disease control, fertilisation, harvesting, marketing and financial resources (du Plessis, 2003).

In developed countries, maize is consumed in the form of eggs, meat and dairy products whereas in developing countries, maize is directly consumed and served to people. Most people eat maize as breakfast cereal. Other than that, maize can be processed as fuel and starch. Starch involves enzymatic reactions that convert into products such as sorbitol, dextrin, sorbic and lactic acid and turn to be household items such as ice cream, syrup, beer, hoe polish, mustard, cosmetics and fireworks. Annually, it is estimated about 8.0 million tons of maize grain are produced in South Africa. Half of the production is from white maize use for consumption of human food (du Plessis, 2003).

2.3.2 Benefits of crustacean foliar application on Maize crop

Previous study of chitosan association on maize seed reported that chitosan concentration at 2-4g/litre give positive effects on endogenous hormone content, alpha-amylase activity and chlorophyll content in seedling leaves (Katiyar et al., 2014). Another study using foliar fertilizer showed the net of photosynthetic rate of maize was decreased after first foliar application but, there was an increase about 10% - 18% of photosynthetic rate over the control group. The higher amount of percentage related to the increase in stomatal conductance and transpiration rate while the concentration of carbon dioxide was similar with control plants. Stomatal conductance is the rate of passage for entering of carbon dioxide or exiting of water vapour through stomata of the leaf (Khan, Prithiviraj, & Smith, 2002).

2.3.3 Application of Chitosan foliar in different crops

Previous study was conducted in randomized complete block design (RCBD) to determine the appropriate applications of chitosan in rice production. Four treatments such as seed soaking without chitosan solution, seed soaking with chitosan solution, seed soaking and soil application with chitosan solution and seed soaking and foliar spraying with chitosan solution were observed. The results showed seed soaking and soil application with chitosan solution four times shows increased rice production whereas seed soaking and foliar spraying with chitosan solution in four times show the plant ability to control disease (Boonlertnirun, Boonraung, & Suvanasara, 2008).

Nowadays, nanofertilizers have become the first approach in agriculture research. Another previous study was conducted to analyse the delivery of chitosan nanoparticles that contain NPK for wheat plants by foliar uptake (Abdel-Aziz, Hasaneen, & Omer, 2016). Chitosan-NPK nanoparticles were applied on leaf surfaces which entered via stomata by gas uptake which avoid direct interactions with soil systems. The uptake of nanoparticles within wheat plants was determined by transmission electron microscopy. Nano particles were absorbed and transported through phloem tissues. The results obtained were increase in harvest index, crop index and mobilization index of determined wheat yield variables compared with control yield variables of wheat plants treated with normal non-fertilized and normal fertilized NPK. The life cycle of nano-fertilized wheat plants was shorter than normal fertilized wheat plants which is 130 days as compared with 170 days for yield production from date of sowing. The ratio of reduction of life span of wheat crop was about 23.5% rather than normal life span of wheat crop (Abdel-Aziz et al., 2016).

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials and Equipment

The materials that involved in this study were included shrimp shells waste, pumpkin peels waste, *Zea mays* seeds, molasses liquid (sugar-by-product), commercial fertilizer and non-chlorinated water. The equipment used in this study were measuring cylinder, beaker, 9L water containers, hoe, bottles, tea strainer, plastic bag, watering can, sprayer, measuring tape and silver shine.

3.2 Crustacean foliar with pumpkin peels preparation

Crustacean foliar was prepared using wastes such as shrimp shells, pumpkin peels and liquid molasses. After all the components were ready, the fermentation period started.

Approximately, 500 gram of shrimp shells were cleaned and later dried under sunlight for 4 hours. Then, one kilogram of pumpkin peels obtained from its fruits and then was dried under sunlight. Other than that, one litre of liquid molasses was measured by using measuring cylinder. Then, the wastes were crushed by food processor. All the components were mixed well in order to allow aeration during fermentation period. This mixture prepared for the usage of two months of planting duration. The mixed ingredients were covered in container. The duration of fermentation process for this fertilizer was about 2 months. All the components were mixed together in a container using a stick.

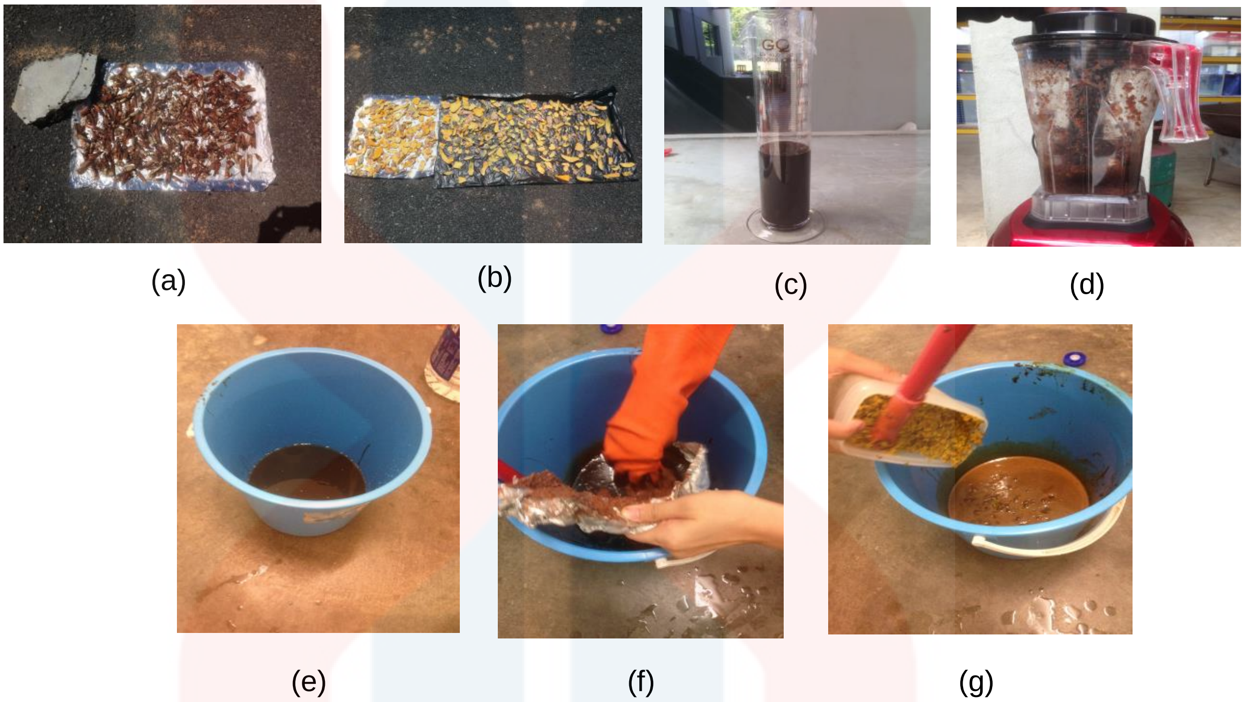
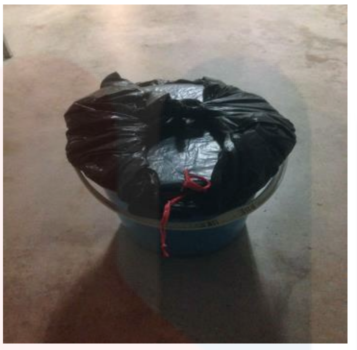


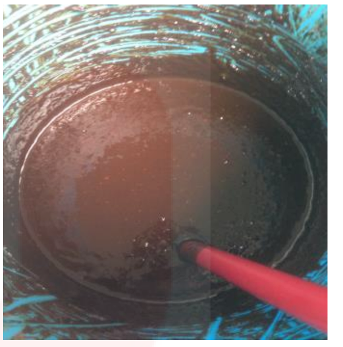
Figure 3.1: Preparation of crustacean foliar. a) shrimp shells were dried under sunlight b) pumpkin peels were dried under sunlight c) 1 L of molasses was measured by using a measuring cylinder d) All materials for foliar crustacean preparation were crushed by using a food processor e) 1 L molasses was added into a container f) crushed shrimp shells were added into a container g) crushed pumpkin peels were added into a container.

3.3 Fermentation period

The mixture were stirred well in order to allow the fermentation process to be taken place. The plastic bag was used to cover up the upper side of the container. The plastic bag was opened once per day for allowing the wasted to be aerated. Soon after 2 months of fermentation period, the foliar fertilizer were ready for the dilution process.



(a)



(b)

Figure 3.2: Fermentation process involved (a) plastic bag and the outcome as (b) fermented crustacean foliar.

3.4 Preparation of planting beds

The planting beds were prepared in Agro Techno Park UMK. The planting beds were prepared by lossen the soil in the planting plot with dimension of 6m x 4m (figure 3.4) and dimensions of planting beds 5m X 0.7m with 0.1m height (figure 3.4). The planting beds were divided into three parts. The silver shine was used to cover the planting beds where the silver side of silver shine was faced direct sunlight to reduce high temperature that may affect the moisture of soil on planting beds. The Maize plants were planted on each of planting bed according to zig-zag pattern. This pattern was used for pollination purpose. The Maize seeds were soaked overnight with dechlorinated water. The soaked seeds were then transferred gently into three planting beds. The total number of Maize plants on three beds were 30 plants where each bed consists of 10 plants. After all seeds were transferred into planting beds, then watering activities took place daily by using watering can.

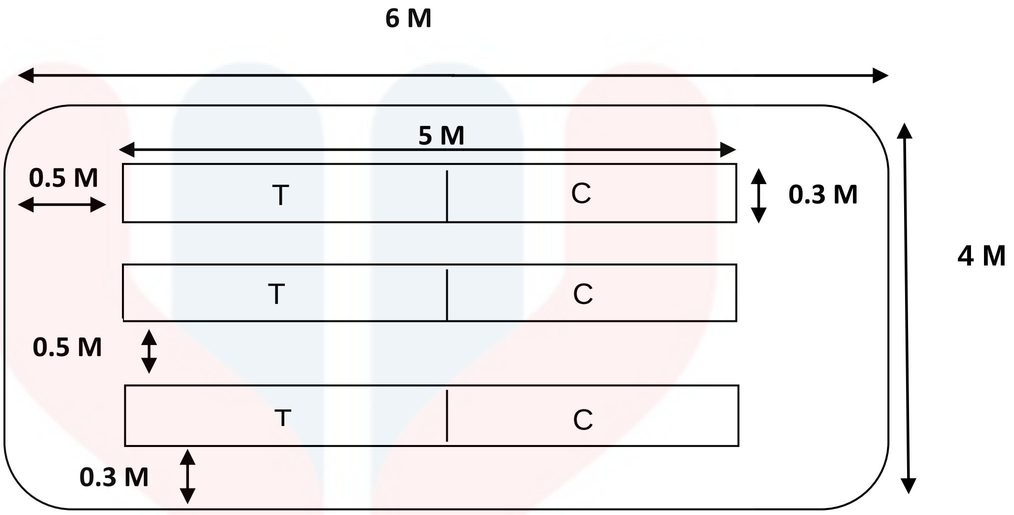


Figure 3.3: Dimension of planting plot and planting bed.

(a) (b)

Figure 3.4: Preparation of planting beds.

3.5 Crustacean foliar dilution and application

After fermentation period, the concentrated foliar was filtered using a strainer and transferred into 500mL empty mineral bottles. The solid residues obtained during filtration were removed and discarded.

For fertilizer application, 1% dilution of crustacean foliar was prepared. Normally, 1.5L of diluted fertilizer was needed for each fertilizer application. For producing 1.5L of foliar, the dilution factor was calculated as 1:100 where 15mL of concentrated foliar was mixed with 1485mL of non-chlorinated water. Then, the foliar was being ready to use and applied on plants twice a week on the stomata of leaves. The stomata on the leaves usually open for absorption process to take place.



(a) (b) (c)

(d)

Figure 3.5: Preparation of concentrated foliar. a) crude crustacean foliar was poured out from container b) and c) filtered by using a strainer d) crustacean foliar in empty mineral bottles.

3.6 Data collection and analysis

The data was collected by observation of plant growth performance parameter. The parameter were included height of maize plants, number of leaves, width and length of leaves. The collected data were analysed by using SPSS version 22.0 and the graphs was tabulated using Microsoft Excel 2013.

CHAPTER 4

RESULTS

4.1 Analysis of element in commercial and crustacean foliar

Analysis of element in fertilizer was conducted to identify the elements content in fertilizer. In this study, two types of fertilizers that involved in conducting element analysis were commercial fertilizer and foliar crustacean foliar. This analysis was conducted using X-ray Fluorescence (XRF) spectrometry. XRF is an elemental analysis technique used to analyse solid, liquid and thin-film samples for both major and trace elements in ppm unit. Crustacean foliar contained raw materials of by-products such as shrimp shells, molasses and pumpkin peels. Preparation of crustacean foliar had been done within two months of fermentation period. The main elements needed in plants are nitrogen (N), phosphorus (P) and potassium (K). The nitrogen content in crustacean foliar and commercial fertilizer were analysed at Malaysia Agricultural Research and Development Institute (MARDI) which located in Serdang, Selangor. Meanwhile, phosphorus and potassium content were analysed at Universiti Malaysia Kelantan (UMK). The concentration of elements in both fertilizers listed in Table 4.1.

Table 4.1: The elements presence in commercial fertilizer and crustacean foliar.

Formula	Concentration (%)	
	Commercial Fertilizer	**Crustacean Foliar**
Al	< 0.0001	0.0364
Ba	0.0014	< 0.0001
Ca	0.0232	0.0878
Cl	0.1670	0.1920
Fe	0.0011	< 0.0010
N	0.3300	0.1900
Mg	< 0.0001	0.2350
Na	< 0.0001	2.840
Mn	0.0012	< 0.0010
P	0.0828	0.1970
S	0.0958	0.1520
Sb	0.0013	0.0017
Sn	0.0015	0.0015
Si	< 0.0001	0.0330
H_2O	99.60	96.20
K	< 0.0001	< 0.0001

Table 4.1 summarized that among from these elements, both fertilizers mostly contain significant amount of water (H_2O). Meanwhile, potassium (K) showed the lowest concentration in both fertilizers less than 0.0001%.

Plants required the major elements such as nitrogen (N), phosphorus (P) and potassium (K). From the table above, the concentration of NPK elements in commercial fertilizer had descending order of N > P > K. Meanwhile, crustacean foliar had descending order of P > N > K. Nitrogen element in commercial fertilizer showed higher concentration compared to crustacean foliar with 14% difference. Other than that, the concentration of phosphorus element in crustacean foliar was higher than commercial fertilizer which was 0.1970% and 0.0828% respectively. Meanwhile, the element of potassium had similar concentration in both commercial fertilizer and crustacean foliar which were less than 0.001%.

Aside from major elements, these fertilizers were also contained elements which also known as trace elements. The element analysis showed the concentration of trace elements in crustacean foliar were higher compared to commercial fertilizer except for Ba, Fe and Mn. Trace elements also involved in the growth performance of the plants. From the analysis, elements in foliar crustacean such as calcium, magnesium, sodium, phosphorus and sulphur were higher concentration than in commercial fertilizer.

4.2 Plant Growth Performance Analysis

Plant growth performance was determined by using several parameters such as height of Maize plants, number of leaves, width and length of leaves. These parameters were involved to determine the effectiveness the application in both commercial fertilizer and crustacean foliar towards Maize plants. Seed germination period was started on day 1. The first application of these two fertilizers was started during day 13 after the day of germination of Maize seeds. The application of these two fertilizers were done twice a week. The parameter data was collected started from day 12. The data was collected every twice a week.

4.2.1 Height of Maize plants

The height of Maize plants was measured in the horizontal position started from the bottom of the botanical roots to the top of the tassel. The plant height was recorded throughout the growing period to determine the effectiveness of both commercial fertilizer and crustacean foliar towards Maize plants growth performance.

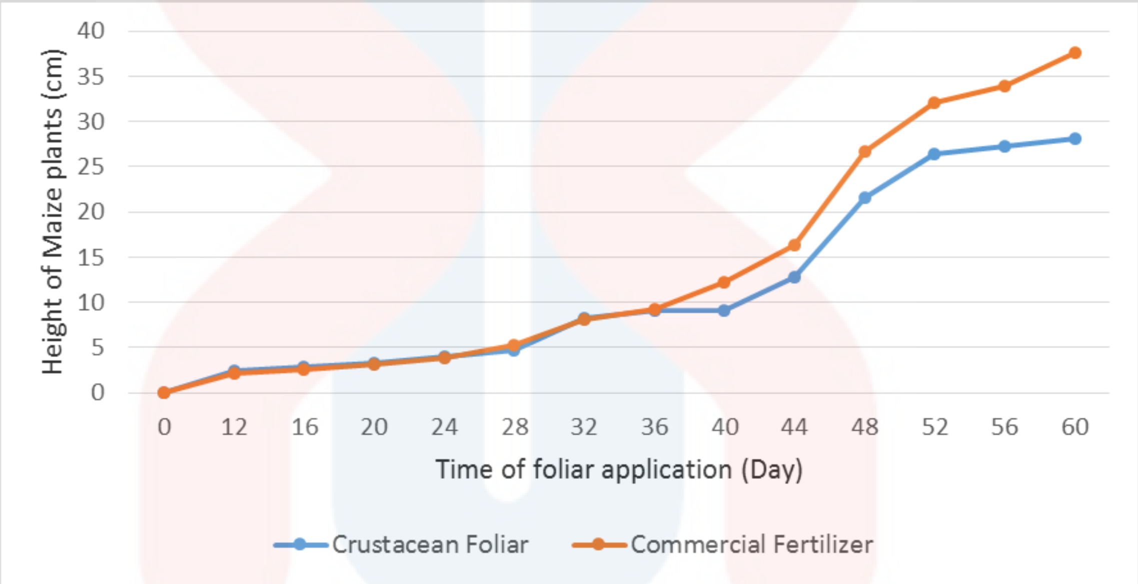


Figure 4.1: Growth performance based on height of Maize plants between commercial fertilizer and crustacean foliar.

Figure 4.1 showed the heights of Maize plants with the application of commercial fertilizer and crustacean foliar. First application of foliar had been done on Day 13 of Maize plantation. Maize height for both fertilizers were increased gradually throughout the whole growing period but being dominated by the commercial fertilizer. The Maize plants for both fertilizers had initial height of 2 cm at Day 12 and started to increase gradually started from Day 13 towards the end of planting period. On Day 20 to Day 24, both plants that were being treated with commercial fertilizer and foliar crustacean fertilizer had same increasing height of 4 cm and then the height of plants with treatment of commercial fertilizer started to increase gradually until Day 60 with maximum height of 38 ± 5.01 cm.

Table 4.2 indicated the final height of Maize plants in both fertilizers. Commercial fertilizer and crustacean foliar showed significance differences in height of Maize plants ($p < 0.05$, 34.01 ± 5.01, 18.00 ± 4.77).

Table 4.2: Mean ± SEM average height of plants in commercial fertilizer and crustacean foliar.

Parameter	Treatments	N	Mean ± SEM	P-value
Height of plants	Commercial Fertilizer	15	34.01 ± 5.01	0.028
	Crustacean Foliar	15	18.00 ± 4.77	

N = Number of Replication

± SEM = Standard error of mean

4.2.2 Number of Leaves

Number of leaves was one of important parameters that recorded throughout the whole cultivation Maize period to determine the effectiveness between commercial fertilizer and crustacean foliar towards Maize plants growth performance.

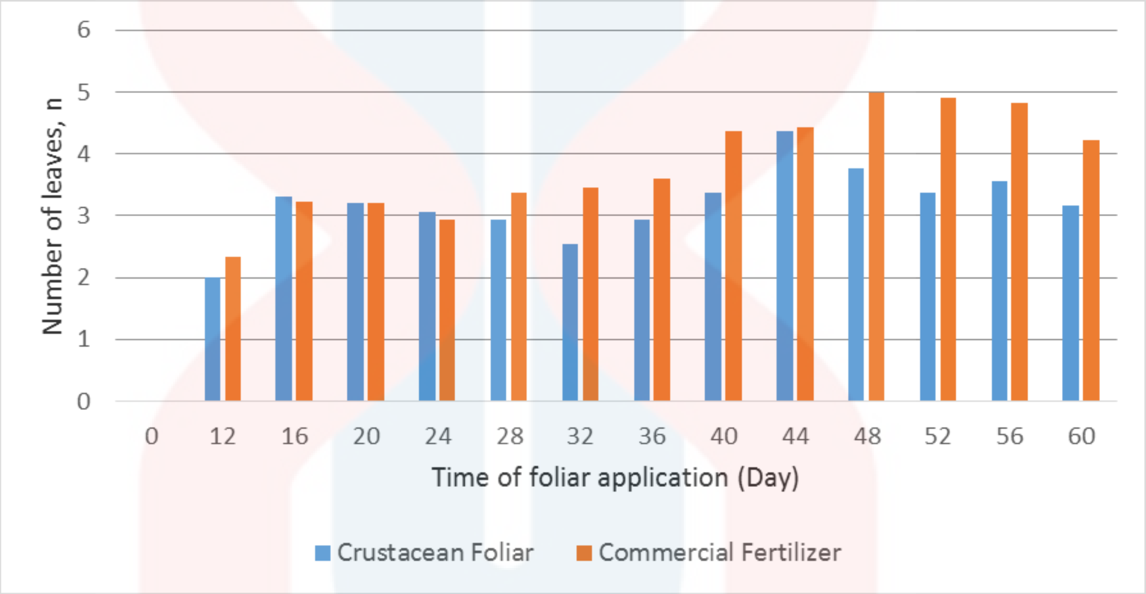


Figure 4.2: Number of leaves between commercial fertilizer and crustacean foliar.

Figure 4.2 showed the number of leaves recorded in both fertilizer plants. The graph pattern for the number of leaves in both fertilizers was fluctuated. Prior to the first application of foliar, the number of leaves in both commercial fertilizer and crustacean foliar were similar with two leaves. After the first application of foliar started from Day 16 to Day 32, the number of leaves in commercial fertilizer was slightly increased with 3 leaves and later two more leaves were developed but on Day 56, 4 leaves were formed. On Day 16 until Day 40, the number of leaves in crustacean foliar was increased with 3 leaves and later one more leaves was developed and formed 3 leaves again on Day 52 and Day 60. Overall, the total number of leaves in both fertilizers were decreased at the end of planting period.

Table 4.3 indicated the final number of leaves in both fertilizers. Commercial fertilizer and crustacean foliar showed significance differences in number of leaves ($p < 0.05$, 3.60 ± 0.434, 1.93 ± 0.408).

Table 4.3: Mean ± SEM average number of leaves in commercial fertilizer and crustacean foliar.

Parameter	Treatments	N	Mean ± SEM	P-value
Number of leaves	Commercial Fertilizer	15	3.60 ± 0.434	0.009
	Crustacean Foliar	15	1.93 ± 0.408	

N = Number of Replication

± SEM = Standard error of mean

4.2.3 Width of Maize leaves

Width of leaves was one of parameters that used to determine the effectiveness between commercial fertilizer and crustacean foliar towards Maize plants growth performance.

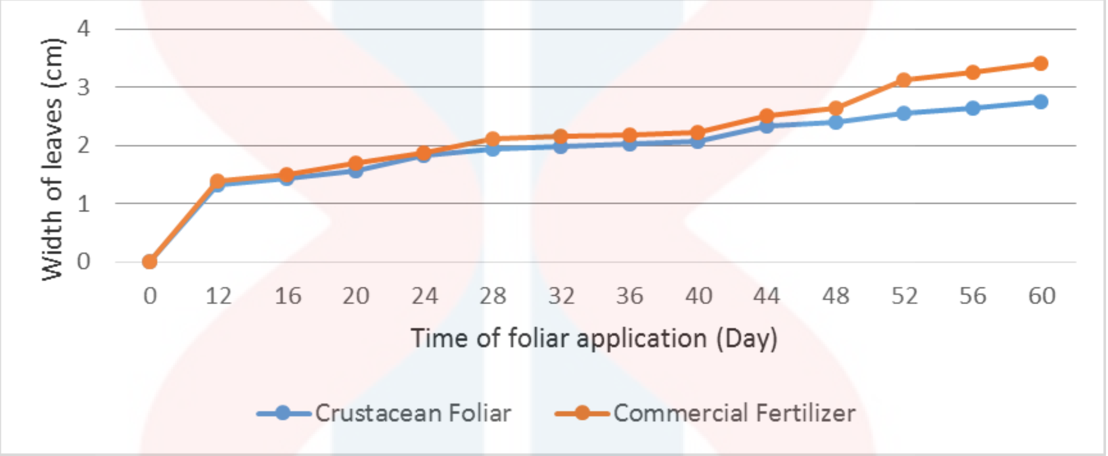


Figure 4.3: Width of leaves between commercial fertilizer and crustacean foliar.

Figure 4.3 showed the width of leaves with the application of commercial fertilizer and crustacean foliar. The Maize leaves for both treatment groups were increased gradually that also being dominated by the commercial fertilizer plant. The width of leaves for both treatment groups was recorded similar at measurement of 1.3 cm and started to increase gradually to 1.8 cm on Day 24. At Day 28, the leaves in commercial fertilizer was widen 0.1 cm compared to crustacean foliar. At Day 24 until towards the end of planting period, the leaves for both treatment groups were started to widen gradually but leaves in commercial fertilizer showed more widen 3.4 cm compared to crustacean foliar treatment.

Table 4.4 indicated the final width of leaves in both fertilizers. Commercial fertilizer and crustacean foliar showed significance differences in width of leaves ($p < 0.05$, 2.97 ± 0.36, 1.66 ± 1.42).

Table 4.4: Mean ± SEM average width of leaves in commercial fertilizer and crustacean foliar.

Parameter	Treatments	N	Mean ± SEM	P-value
Width of leaves	Commercial Fertilizer	15	2.97 ± 0.36	0.016
	Crustacean Foliar	15	1.66 ± 1.42	

N = Number of Replication

± SEM = Standard error of mean

4.2.4 Length of Maize leaves

Length of leaves was one of parameters that recorded throughout the whole cultivation Maize period to determine the effectiveness between commercial fertilizer and crustacean foliar towards Maize plants growth performance.

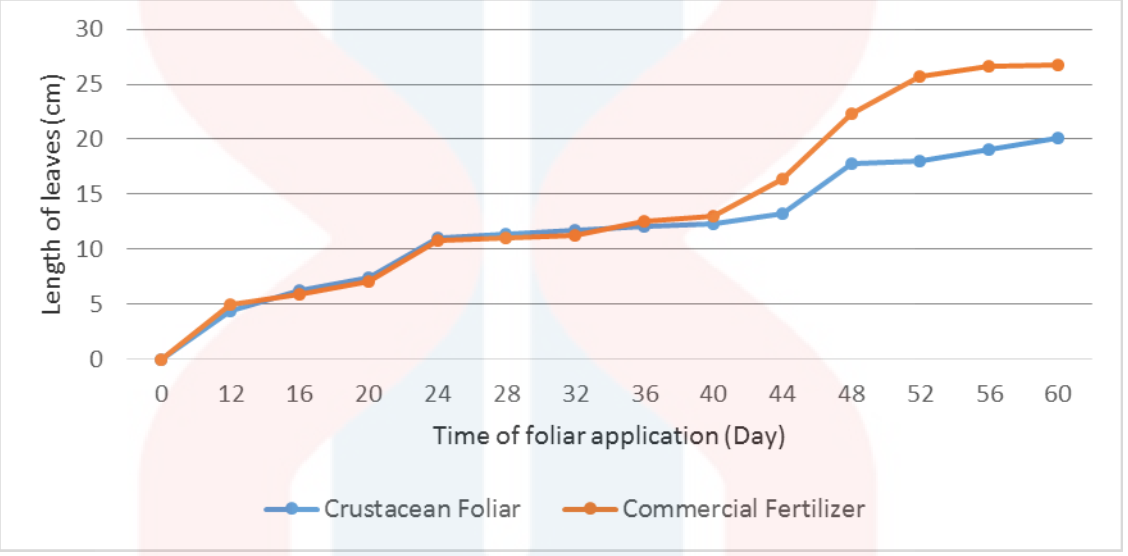


Figure 4.4: Length of leaves between commercial fertilizer and crustacean foliar.

Figure 4.4 showed the length of leaves with application of commercial fertilizer and foliar crustacean fertilizer. The leaves length in both treatment groups were increased throughout the growing period and being dominated by the commercial fertilizer. At the beginning of plantation period, the leaves in commercial fertilizer had length of 5 cm long whereas the leaves in crustacean foliar had length of 4.4 cm. Then, the leaves in both treatment groups started to increase gradually until Day 40. At Day 40 to Day 56, the leaves in commercial fertilizer fast elongated to 26.6 cm and remained constant towards the end of planting period. Meanwhile, the leaves in crustacean foliar fast elongated to 17.7 cm at Day 48 and started to increase gradually until the end of Day 60 with the value of 20 cm.

Table 4.5 indicated the final length of leaves in both fertilizers. Commercial fertilizer and crustacean foliar showed significance differences in width of leaves ($p < 0.05$, 23.89 ± 2.91, 12.74 ± 3.02).

Table 4.5: Mean ± SEM average length of leaves in commercial fertilizer and crustacean foliar.

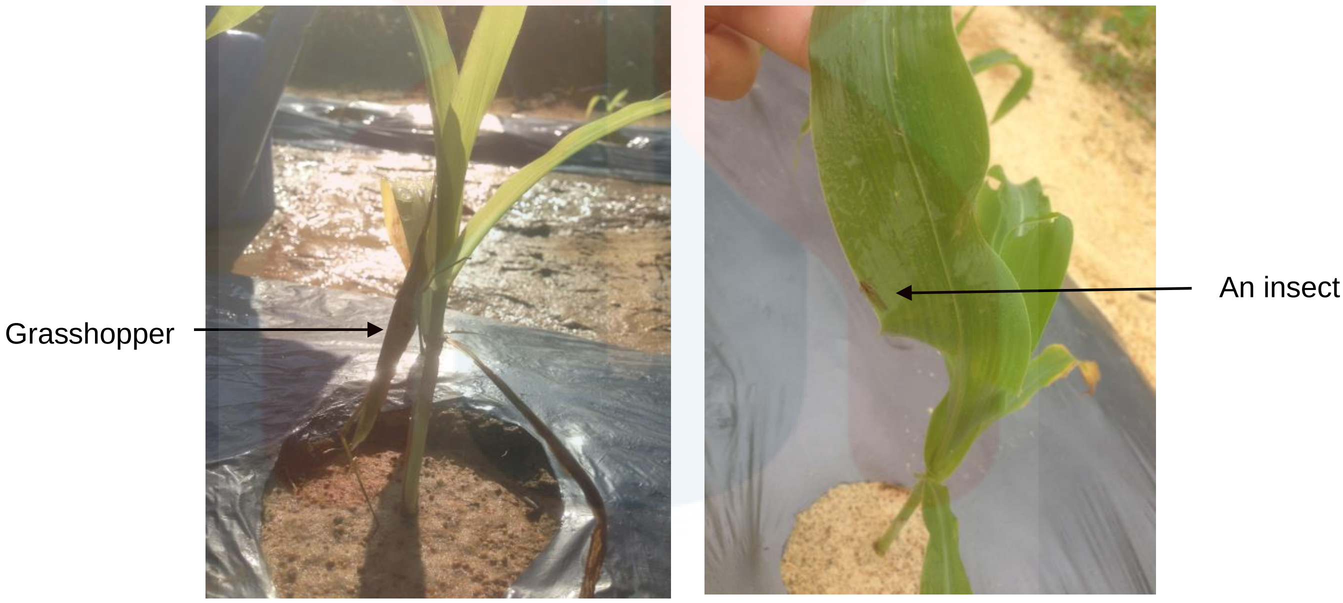
Parameter	Treatments	N	Mean ± SEM	P-value
Length of leaves	Commercial Fertilizer	15	23.89 ± 2.91	0.013
	Crustacean Foliar	15	12.74 ± 3.02	

N = Number of Replication

± SEM = Standard error of mean

4.2.5 Presence of insect pest during plantation period

Figure 4.5 (a) showed one of Maize plants treated with foliar crustacean fertilizer had been infested by a grasshopper on Day 30. Meanwhile figure 4.5 (b) showed one of Maize plants treated with commercial fertilizer also had been approached by an insect on Day 43.



(a) (b)

Figure 4.5: Presence of insects in on Maize plants. (a) A grasshopper approached the crustacean foliar plant stem (b) An insect was observed on commercial fertilizer plant leaf.

4.2.6 Formation of tassel

Tassel is importance for development of fruits. It involves in pollination process. The Maize plants produce an individual male and female in a same plant. At initial stage, both flowers are bisexual but during the development period, both flowers become asexual where tassel is a male flower and ear is a female flower. The pollination occurs when pollen grains from anther in tassel pollinate to ear of Maize plants and fertilization occur resulting in a kernel.

Overall, there were 11 tassels that already formed in both treatments of Maize plants. three tassels formed in plants treated with crustacean fertilizer whereas the rests obtained from plants treated with commercial fertilizer. The first formation of tassel was observed in plants treated with commercial fertilizer. One of plants treated with commercial fertilizer occurred in Day 44. Meanwhile, the first formation of tassel in plants treated with crustacean fertilizer occurred in Day 56.

CHAPTER 5

DISCUSSION

5.1 Analysis of element in commercial and crustacean foliar

Crop plants need 17 types of nutrients in order to complete their life cycle. The nutrients are divided into two types which are macronutrient and micronutrient groups. Macronutrients such as nitrogen (N), phosphorus (P), potassium (K), carbon (C), hydrogen (H), oxygen (O), calcium (Ca), magnesium (Mg) and sulphur (S). Meanwhile, micronutrients such as chlorine (Cl), Nickel (Ni), molybdenum (Mo), boron (B), manganese (Mn), iron (Fe), copper (Cu) and zinc (Zn) (Fageria, Filho, Moreira, & Guimarãe, 2017).

From Table 4.1, both commercial fertilizer and crustacean foliar mostly contained of water (H_2O) element whereas potassium (K) showed the lowest concentration element. As mentioned above, plants are needed in higher amount for macronutrients such as NPK elements. From the element analysis table, it can be concluded that the amount of NPK elements in commercial fertilizer and foliar crustacean fertilizer were too little which lacking of sufficient nutrients of NPK.

Nitrogen is important in photosynthesis process which is major part of the chlorophyll production in plants. Deficiency of nitrogen may contributed to the stunted growth, the colour changes of leaves from pale green to light yellow colour and early maturation of some crops. Phosphorus is needed in large amounts in young cells such as shoot and root tips where cell division rapidly occurred. Deficiency in phosphorus may lead to poor seed and root development, stunted growth since P is needed in higher amount during early stages of cell division and late maturity. Potassium is also important in photosynthesis and protein synthesis that may resulted in stunted growth if plants lack of it (Silva & Uchida, 2000).

Crustacean foliar contained higher in trace elements such as calcium (Ca), magnesium (Mg), sodium (Na), phosphorus (P), sulphur (S) and chlorine (Cl) compared to commercial fertilizer. Crustacean shells and pumpkin peels were the main materials in crustacean foliar that could benefits to the Maize plants. Calcium carbonate in crustacean shells involved in development of Maize roots. Other than that, pumpkin peels also contained calcium. Previous study reported that calcium at concentration 1.0 mmol/l effects gave better effects on the roots growth of Maize (Kurtyka, Malkowski, Kita, & Karcz, 2008). Other than that, magnesium crucial in protein development, Maize plant respiration and contained in chlorophyll molecule for photosynthesis process. Chlorine involved in protein development, maturity of crop and photosynthesis.

Other than that, molasses liquid also added into crustacean foliar. Molasses is importance in a fertilizer as it provided food for microorganisms in soil and benefits to the plants. Molasses was a sugar by-product that attracted the microorganisms such as bacteria to eat the molasses and increase the number of population of bacteria. The addition of molasses into crustacean fertilizer helped to grow the population of microorganisms. These microorganisms aid to degrade completely another sources of materials in crustacean foliar included shrimp shells and pumpkin peels.

5.2 Plant growth performance analysis

5.2.1 Height of Maize plants

The lack of nutrients supply for plants may affect the growth performance of the plants. The height of Maize plants that were being treated with commercial fertilizer and crustacean foliar were stunted due to lack of nutrients. The height of Maize plants in both commercial fertilizer and foliar crustacean fertilizer in Day 60 were only reaching 37.6 cm and 28.1 cm respectively (Figure 4.1). Nitrogen element in fertilizer influenced the increase height of Maize plants. From the previous studies, the high application of nitrogen fertilizer gave better performance in plant height (Amin, 2011). Another study stated that deficiency of nitrogen element may resulted in stunted growth plant development (Silva & Uchida, 2000).

5.2.2 Number of Leaves

Figure 4.2 demonstrated that the amount of leaves in commercial fertilizer had better performance compared to crustacean foliar as the result of foliar fertilizer application. The commercial fertilizer plants had better performance towards number of leaves due to high nitrogen content compared to plants that were treated with crustacean foliar. The concentration of nitrogen in commercial fertilizer and crustacean foliar were 0.3300% and 0.1900% respectively (Table 4.1). Elements that are needed by maize plants for growth of leaves are both nitrogen and phosphorus soon after germination. Majority of nitrogen was needed during the period of maximum growth especially in tasselling and silking. From the previous studies, increase nitrogen fertilizer lead to increase in plant height and leaf number (Amin, 2011). From this findings, Maize plants treated with both commercial fertilizer and crustacean foliar was reduced in number of leaves at the end of planting period. The lower number of leaves was due to insufficient nutrient of phosphorus. Phosphorus importance in photosynthesis and stomata of the leaves. Lack of potassium in the plants may decreased the photosynthetic rate, formed yellow colour in the vein of leaves and fastened the senescence age of the plants (Zhao et al., 2016). The acceleration of senescence age of the Maize plants may contributed to the death of leaves and the number of leaves reduced.

Concentration of phosphorus in commercial fertilizer was 0.0828% (Table 4.1). Even though the concentration of phosphorus in crustacean foliar was quite high, growth performance of commercial fertilizer showed better results. Phosphorus is closely concerned with many growth processes in crop plants. It is involved in many biochemical reactions and related with metabolism of protein, carbohydrates and fats as well as active in the breakdown of carbohydrates. Phosphorus is another nutrients that are limiting yield for maize production. Phosphorus affects the growth of leaf in maize plants. Factors that involve for P availability to crop plants which including the form of native soil phosphorus, type of phosphorus applied on the soil and the reaction.

5.2.3 Length and Width of Leaves

Overall of findings indicated that plants that being treated with commercial fertilizer had better performance towards width of leaves compared to crustacean foliar with 3.4 cm and 2.8 cm respectively. This is due to higher concentration of nitrogen content in commercial fertilizer which may contributed to better performance of Maize plants. Leaf area may be affected by the rate of nitrogen applications, where high rate of nitrogen may resulted to bigger leaf area. This can be accepted with the previous studies that reported higher rate of nitrogen may promoted the leaf area during vegetative development and also could help to maintain the functional of leaf area during the growth period.

From Figure 4.4, treatment of plants with commercial fertilizer showed better performance towards length of leaves compared to crustacean foliar. At the final of Day 60, the length of leaves for commercial fertilizer was 26.8 cm which higher than in crustacean foliar that only 20.1 cm. The elongation rate of Maize leaves involved of nutrient of potassium uptake by plants. Potassium is crucial in stomatal opening and closing and protein synthesis. Lack of potassium may contributed to the reduction of leaf area index through alteration of plant-water relationships that reduce the elongation rate (Jordan-Meille & Pellerin, 2004). The leaf development also were reduced due to high concentration of chloride in leaves. Another study reported that decrease of soybean leaf development came from crustacean shells that contained higher amount of chlorine (Ah, Horiuchi, & Miyagawa, 2017).

5.2.4 Presence of insect pest during plantation period

After fertilizer application, insect pest were observed on the leaves of maize plants that were applied with crustacean foliar and commercial fertilizer starting on Day 30 and Day 43 respectively (Figure 4.5). Presence of these insects resulted in Maize plant damaged particularly on leaves. Abundance of nitrogen element may lead to more insect existence. Previous study reported that the higher application of nitrogen fertilizer towards cotton plants increased the number of insect presence due to required nitrogen in their diet (El-Zahi et al., 2012).

5.2.5 Formation of tassel

Tassel is importance for development of fruits. It involves in pollination process. The Maize plants produce an individual male and female in a same plant. At initial stage, both flowers are bisexual but during the development period, both flowers become asexual where tassel is a male flower and ear is a female flower. The pollination occurs when pollen grains from anther in tassel pollinate to ear of Maize plants and fertilization occur resulting in a kernel.

Tassel formation was initially started on three weeks after the Maize plants grow (Ransom, 2013). Another studies was conducted in Hawaii reported the reproductive stage of ear and tassel was started about 3 to 4 weeks after planting and meiotic division started formed on Day 28 (Brewbaker, 2003). However, finding in present study showed the formation of tassel on Maize plants treated with both commercial fertilizer and crustacean foliar were delayed later than 3 weeks after the

Maize plants grow. Environment factors could contributed to the delay of tassel formation such as hot or dry condition. At this stage, the soil need to be moist for developing of tassel and pollination to occur. The most common factor that reduce production of maize is soil water deficiency due to high temperature. Flowering and early seed development are the stage when maize is very susceptible to drought stress (Sangoi & Salvador, 1998). Drought at flowering may produce the pollen but inhibits ear and silk development, thus delay the pollination and reduce maize production.

CHAPTER 6

CONCLUSION

6.1 Conclusion

As a conclusion, the outcome of study had shown some findings about comparison between two types of fertilizer towards Maize (*Zea Mays*) plants growth performance. The findings were recorded based on parameter of plant height, number of leaves, width and length of leaves as well as tassel formation. The effects of crustacean foliar application on Maize plants growth performance were slow growth, fallen of leaves and failure of completing tassel and fruits development due to lack of nutrients. The effectiveness of crustacean foliar was compared with commercial fertilizer where commercial fertilizer gave better plant growth performance. Plants applied with commercial fertilizer had reached 34.01 ± 5.01 cm height while plants applied with crustacean foliar only reached 18.00 ± 4.77 cm height. Based on the findings, it indicated the growth performance of Maize plants based on the parameters plant height, width and length of leaves as well as number of leaves showed significance difference between both fertilizers. From this study, the hypothesis H_0 was accepted which indicated the crustacean foliar was not enhanced the growth performance of Maize plants compared to commercial fertilizer due to some lack of nutrients in crustacean foliar that lead to deficiency symptoms of the Maize plants.

6.2 Recommendation

From this study, it can be suggested crustacean foliar had better outcome compared to commercial fertilizer if fermentation period was longer during preparation of crustacean foliar. Based on this study, fermentation period was done only within 2 months which was not enough for all materials in crustacean foliar to degrade completely before readily apply to Maize plants. Second suggestion is the usage of molasses liquid could be replaced with effective microorganisms (EM) solutions that contain microbes which can improve the soil, plant growth and yield. Other than that, increase the concentration of foliar application. Based on this study, the concentration of both fertilizers used was 1%. The inadequate concentration and lack of sufficient nutrients in fertilizer lead to decrease in leaves number, width and length of leaves as well as insufficient height of Maize plants.

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APPENDIX A

Table A.1: One-way ANOVA

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Number of leaves	Between Groups	20.833	1	20.833	7.826	.009
	Within Groups	74.533	28	2.662		
	Total	95.367	29			
Width of leaves	Between Groups	12.936	1	12.936	6.633	.016
	Within Groups	54.605	28	1.950		
	Total	67.542	29			
Length of leaves	Between Groups	931.992	1	931.992	7.058	.013
	Within Groups	3697.476	28	132.053		
	Total	4629.468	29			
Height of plants	Between Groups	1923.201	1	1923.201	5.350	.028
	Within Groups	10065.937	28	359.498		
	Total	11989.139	29			