Influence of organic compost on the growth of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*)

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DECLARATION

I hereby declare that the work embodies 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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I certify that the report of this final year project entitled "Influence of the organic compost on the growth of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*)" by Nur Aqazah Binti Bungsu, matric number F15A0132 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Agriculture Technology) with Honours, Faculty of Agro-Based Industry, Universiti Malaysia Kelantan.

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Pengaruh kompos organik pada pertumbuhan choy sum (*Brassica rapa var parachinensis*) dan pak choi (*Brassica rapa var chinensis*)

ABSTRAK

Kesuburan tanah adalah penting untuk pengeluaran tanaman lestari. Baja kimia adalah mahal dan boleh mendatangkan impak negatif kepada tanah dalam jangka masa yang panjang. Kompos organik boleh bertindak sebagai cara alternatif untuk mengatasi masalah ini. Oleh itu, satu kajian dijalankan untuk mengkaji pengaruh kompos organik (gabungan daripada sisa sayur-sayuran dan tinja kambing) terhadap pertumbuhan choy sum (*Brassica rapa var parachinensis*) dan pak choi (*Brassica rapa var chinensis*) di bawah keadaan nurseri di Universiti Malaysia Kelantan, Kampus Jeli. Spesies bioassay telah dirawat dengan baja NPK komersil dan kompos organik pada kadar aplikasi 250 kg ha^{-1} dan 15000 kg ha^{-1}, manakala kawalan pada 0 kg ha^{-1}. Hasil daripada kajian ini menunjukkan kesan rangsangan daripada rawatan kompos organik kepada choy sum dan pak choi. Parameter ketinggian tumbuhan, berat tumbuhan dan kandungan klorofil untuk choy sum dan pak choi meningkat dengan ketara ($P \leq 0.05$) manakala panjang akar menunjukkan keputusan yang tidak ketara ($P \leq 0.05$) berbanding dengan kawalan. Oleh itu, kajian ini membuktikan bahawa pertumbuhan maksimum choy sum (*Brassica rapa var parachinensis*) dan pak choi (*Brassica rapa var chinensis*) berjaya dicapai apabila tumbuhan itu ditambah dengan kompos organik yang merupakan sisa sayur-sayuran bercampur dengan tinja kambing. Walaupun baja NPK komersil menunjukkan kesan yang sama kepada kompos organik, nilai pameran kompos organik lebih tinggi dalam meningkatkan pertumbuhan choy sum dan pak choi. Kesimpulannya, hasil keseluruhan kajian menunjukkan bahawa kompos organik daripada gabungan sisa sayur-sayuran dengan tinja kambing boleh digunakan untuk memastikan tumbuhan choy sum dan pak choi yang lebih sihat dan kuat.

Kata kunci: kompos, choy sum, pak choi, baja komersial NPK, prestasi pertumbuhan

Influence of organic compost on the growth of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*)

ABSTRACT

Soil fertility is important for sustainable crop production. Chemical fertilizers are expensive and can bring a negative impact to the soil in the long term. Organic compost can act as an alternative way to overcome this problem. Therefore, a study was carried out to investigate the influence of organic compost (vegetable waste mixed with goat dung) on the growth of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*) under nursery condition in University Malaysia Kelantan, Jeli campus. The bioassay species were treated with commercial NPK fertilizer and organic compost at an application rate of 250 kg ha^{-1} and 15000 kg ha^{-1}, respectively while control at 0 kg ha^{-1}. The result from this study showed the stimulating effect from the treatment of organic compost to choy sum and pak choi. The parameters of plant height, plant weight and chlorophyll content for choy sum and pak choi are significantly increased ($P \leq 0.05$) while the root length shows insignificant results ($P \leq 0.05$) compared to control. Thus, this study proved that the maximum growth of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*) were successfully achieved when the plants were supplemented with organic compost which is vegetable waste mixed with goat dung. Even though commercial NPK fertilizer shows the similar effect to organic compost, the organic compost exhibit higher value in increased the growth of choy sum and pak choi. To conclude, the overall results of the study indicate that the compost of vegetables waste mixed with goat dung can be applied and used to ensure the healthier and vigorous growth of choy sum and pak choi.

Keywords: organic compost, choy sum, pak choi, commercial NPK fertilizer, growth performances

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LIST OF SYMBOLS

g	Gram
kg	Kilogram
ha^{-1}	Per hectare
cm	Centimeter
cm^2	Centimeter square
m	Meter
m^2	Meter square
nm	Nanometre
%	Percentage
^{o} C	Degree celcius

LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
SPSS	Statistical Package for the Social Sciences
HSD	Honest Significant Different
Sig	Significant
SD	Standard deviation
^{o} N	North
^{o} E	East

CHAPTER 1

INTRODUCTION

1.1 Research background

About 10 000 years ago, agriculture has grown rapidly in term of the size of the production and its yield. Despite the practice of irrigation, crop rotation, the use of fertilizers and pesticides has long been introduced, major achievements have only occurred in the last century. During the extension period, new technologies and plants have been integrated. Agriculture is an indispensable field of human life and nature. In the hierarchy of ecosystems in some components of life that form a mutually beneficial chain and if one interrupt in the chain, it will affect the survival of other living creatures so that the whole chain needs to be preserved. Over the last 50 years, agricultural activity has become increasingly dependent on chemical fertilizers for high yields. In fact, it is estimated that around the world, 2 to 5% of all the materials used for fertilizer production are composed of synthetic nitrogen (Dewi, 2016).

Fertilizers are important for plant growth because it provide plant nutrients which are not adequately supplied by the soil. Fertilizers can be divided into two broad groups which are organic and inorganic. An organic fertilizer is derived from a living plant or animal source whether in liquid or solid form. Inorganic or call as chemical fertilizer are usually manufactured such as commercial NPK fertilizer. It consist the nutrients in forms that are readily utilized by plants such as nitrogen, potassium and phosphorous. Chemical fertilizer is also known as fast release of the nutrients compared to organic fertilizer. In spite, the use of organic fertilizer can improves the physical structure of soil and increases the organic matter in the soil (Kluepfel & Lippert, 2017).

According to Federal Agricultural Marketing Authority, FAMA (2011), the demand for local vegetables is expected to increase from 1.6 million tonnes in 2010 to 2.4 million tonnes in 2020 with a growth of 4.5% per year. In line with the trend in developing countries, per capita consumption of vegetables is expected to grow by 2.6% per year from 55 kilograms to 70 kilograms per year over the same period. In order to meet the needs of customers in terms of quality and quantity, the production of vegetables must be increase. One of the efforts to improve the results can be done through fertilization. Nowadays, the uses of organic compost are highly recommended for conservation system. The substance in organic compost can improve the content of soil organic matter and contribute to nutrient supply, improve physical properties of the soil, prevent erosion and increase the activity of soil microorganisms (Dewi, 2016).

Brassica is the most famous and had a high demand among other vegetables (Fatimah, 2007). It is a very diverse plant genus belonging to the family Brassicaceae. It contains the species that are have great economic importance such as oilseed, ornamental plants and vegetables crops that are the main food of global food supplies with cereals. Almost all the parts of this species that have been developed to be eaten including seeds, stems, flowers, leaves, buds and roots (Wong, 2016). Choy sum (*Brassica rapa var. parachinensis*) and pak choi (*Brassica rapa var chinensis*) was selected as a test plant for determine the effect of vegetables waste mixed with goat dung as organic compost.

1.2 Problem statement

Nowadays, many farmers are still planting in land areas that have shown less favorable in term of their agricultural produce due to the soil has lost its nutrients (Simon, 2012). The use of chemical fertilizer or mineral commonly referred as an inorganic fertilizer can increase the crop production however it will leave a negative effect towards the environment in the long time periods. It also can destruct the structure and texture of the soil in which later on can lead to soil acidity and soil erosion as a consequences of nutrients leaching effects (Omidire, Shange, Khan, Bean & Jewel, 2015). In some way, by applying the chemical fertilizers all alone do not cater the all good nutrients in the correct amount that are required by the plants itself. Moreover, the chemical fertilizer also can make the soil run out of organic matter content, thus can impact the soil physical and biological properties (Verma, Abhishek, Pradhan, Singh & Singh, 2017). In addition, the presence of heavy metals in the soil due to increase in geologic and anthropogenic activities also cause reduction in growth, performance and yield of the crop (Chibuike & Obiora, 2014).

Moreover, it is expected that the use of organic waste to decay will improve the crop productions. There are many organic matter contain in organic waste that can be used as a fertilizer (Simon, 2012). Goat dung and vegetable waste is an example of organic waste that is easy to get and can reduce the pollution.

The use of the prepared compost is actually the excellent remedy in way conserving the productivity besides the quality of the soil and partial substitution of mineral fertilizer. Hence, it is one of the strategy to lower the dependency of chemical fertilizer via the used of compost from mixed of vegetables waste and goat dung. So, compost from vegetables waste and goat dung can be the best option as natural fertilizer as it was proven in many studies had shown positive results to the test plant species. Therefore, the reliance to the chemical fertilizers is much reduced and also reduced the impact to the environment.

1.3 Hypothesis

H_0: Organic compost could not increase the growth performance of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*).

H_1: Organic compost would increase the growth performance of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*).

1.4 Objectives

To investigate the effect of organic compost on the growth of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*).

1.5 Scope of study

The main focus of the study is to enhance the growth of leafy vegetables which are choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*) by applying the combining the vegetable waste and goat dung by using composting process in which potentially act as soil conditioner and soil enricher.

1.6 Significance of study

By using vegetable waste and goat dung as composts, it gives many benefits to the farmers and environment. In 2013, Hariz, Ong, Ain and Fauzi has stated the composting process is the effective way for reducing the amount of disposed organic waste and produces value added products to optimize its use for agriculture activity. The advantages of combining the vegetables waste and goat dung besides being a soil conditioner, it is also an adsorbents of heavy metal from the soil which might affect the growth of plants. Moreover, by using vegetables waste as fertilizer it can reduce the volumes of waste thrown in open landfill sites which in turn reduce toxic gasses releases by waste site.

CHAPTER 2

LITERATURE REVIEW

2.1 Choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis)*

2.1.1 Origin, taxonomy and distribution of choy sum (*Brassica rapa var parachinensis*)

Brassica is a very diverse plant genus belonging to the family Brassicaceae. It contains the species that are have great economic importance such as oilseed, ornamental plants and vegetables crops that are the main food of global food supplies with cereals. Almost all the parts of this species that have been developed to be eaten including seeds, stems, flowers, leaves, buds and roots. *Brassica rapa* is the initially domesticated species in the Mediterranean region that grows to Scandinavia, Germany, Central Europe and eventually to Asia. Along the biological journey, great local variations in growing were cultivated. For example, *B. rapa* is grown as an agricultural crop in China whereas in India it is grown as an oilseed crop (Wong, 2016).

B. rapa var parachinensis or known as choy sum is a derivative of *B. rapa var chinensis* (Pak choi) and a sub-species among seven vegetables groups of *B. rapa*. The other names of choy sum are green caixin stem or chinese flowering cabbage. The choy sum is considered as leaf neeps and distinguished from the oil-yielding turnip rapes. It is comes from Central China and is commercialized for a flowering stem that can be eaten along with its leaves. Currently, the region of cultivation are includes in the southern and central China, in the western region of India and in Southeast Asia countries such as Indonesia, Malaysia, Vietnam and Thailand (Wong, 2016). The taxonomy of the choy sum is described as below:

Kingdom	: Plantae
Division	: Tracheophyta
Class	: Angiospermae
Order	: Papaverales
Family	: Brassicaceae
Genus	: Brassica
Species	: *Brassica rapa var parachinensis*

2.1.2 Morphological characteristics of choy sum (*Brassica rapa var parachinensis*)

Choy sum is an annual vegetable that consist of tap roots and its height varies from 20-30 cm with erect or sometimes prostrate growth habit. It is characterized by yellow flowers borne on slight fleshy stems 0.5 to 1 cm in diameter and is small in comparison with other leafy cabbages. Flowering of choy sum occurs when there are about 7- 8 leaves on the plant. Next, there are few leaves in the rosette, usually with only 1-2 leaf layers. There are long or short petiolate, oblong, bright green, stem leaves. These may be glabrescent to glabrous, green to purple-red and finely toothed when young. Lower stem leaves are ovate to nearly orbicular while upper stem leaves pass into narrow bracts. Inflorescences form as a terminal raceme, elongating when in fruit (Wong, 2016).

2.1.3 Origin, taxonomy and distribution of pak choi (*Brassica rapa var chinensis*)

Brassica rapa var chinensis or known as Pak choi, Bok choi and Tat soi is originated in Southeast Asia and have been cultivated in China and Japan for a long time since 5th century AD, where they are also widely naturalized. This species can be possibly cultivated in climatic zone of Central Europe from spring to winter because of not having high thermal needs and possessing a rather short vegetation period. Leaves of the crop can be consumed from a stage of transplant, but it is recommended to harvest rosettes after 50 to 60 days from sowing or 30 to 40 days from transplanting. The crisp leaves and thick petioles of bitter taste are excellent for cooking as a boiled vegetable. Their fleshy green or white petioles and leafy greens are used from the whole young plants, either cooked in soups, stir-fries or salted and fermented into a can know as Pak choi pickle (Funda, 2016). The taxonomy of the pak choi is described as below:

Kingdom : Plantae

Division : Tracheophyta

Class : Angiospermae

Order : Papaverales

Family : Brassicaceae

Genus : Brassica

Species : *Brassica rapa var chinensis*

2.1.4 Morphological characteristics of pak choi (*Brassica rapa var chinensis*)

Pak choi is a biennial plant that has been grown as annual vegetable. The appearance is like lettuce. This vegetable is known for the juicy, crisp texture of its leaf stalks and the sweetness of its flowering shoots. The leaves are broad and spoon-shaped. It has shallow roots and grown quickly. This species have light or dark green leaves colour forming a kind of rosette, with succulent light green or white petioles. Its height varies from 10-45 cm with erect or sometimes prostrate growth habit (Wanitprapha, Huggins & Nakamoto, 1992).

2.1.5 Ecological requirement

Choy sum and pak choi is a cool season crop that prefers uniform conditions, moderate moisture levels and reasonable sunlight. Optimum temperature is within 23-35 C. High temperatures may result in thinner, tough and less sweet shoots, or bolting. Excessive moisture can damage the leaves and their quality. Choy sum and pak choi will grow on a wide range of soil types if they are fertile and high in organic matter. Soil should be well drained and have an ideal pH of 6.0 to 7.0. When pH falls below 5.0, it is unfavourable for healthy growth. Seeding rate for choy sum and pak choi is 1.5 kg per hectare and recommended spacing is 20 cm within rows and 10 cm between plants. For mineral soil, organic fertilizer can be added by basal dressing 4 ton per hectare into soil bed to ensure better growth of the plant. Side dressing with NPK fertilizer 15-15-15 can be carried out at the second and third weeks after sowing (Wong, 2016).

2.1.6 Nutritional benefits

Brassica vegetables are characterized by high water content, low caloric value, high protein content, carbohydrates, fiber, vitamins, minerals and secondary plant metabolites. In humans, the last given issues have anti-carcinogenic, antioxidant, antibacterial and antiviral effects, and they promote the immune system and reduce inflammation. However, by consuming Brassicas vegetables, the development of cardiovascular diseases and illnesses associated with ageing can be prevented (Funda, 2016).

2.1.7 Production and economic importance

Fatimah (2007) reported that green mustard is among the top five vegetables in terms of per capita consumption expressed on a fresh weight basis in Malaysia. The statistics from the Department of Agriculture (DOA, 2013) show that the hectare of brassica in Malaysia has grown rapidly from 2009 (around 7036) to 2013 (around 14579 hectares) while the harvest area covers 14291 hectares. The production is about 250,060 metric tons which contributes to the income of RM 745,178,000 for the vegetable industry (DOA, 2013). According to DOA (2013), Johor has the largest harvesting area for brassica, which is about 4471 hectares and thus brassica is exported to the major export markets of Malaysia's vegetable industry which is Singapore.

2.2 Compost

Composting is an alternative solid waste management system; it can be used to recycling of organic materials into useful products. In addition, it can also be used to control the increase in waste. This process is considered the most efficient, environmentally safe and as agronomically as possible where the compost can be used as soil conditioner, organic fertilizer also as it contains high nutrients for the soil. The microbial community in compost, which are bacteria, fungi and worms can also stabilize the degradable organic matters. The performances of the composting process also will depend on the characteristics of the waste because composting is only suitable for waste that is biodegradable. The application of compost can improve the properties of the soil that are badly required of renewal, as it can increase the organic carbon contents in the soil. In the meantime, compost also acts as a soil infiltration rate, water retention capacity and tilth (Suhas & Hemali, 2018).

Mathur, Owen, Dinel and Schnitzer (1993) stated that the stability or maturity of compost is an important factor affecting the successful use of composts in agriculture. This fact is supported by Keeling et al. (1994) which mentioned the application of unstable composts can cause low plant growth and damage to crops by competing for oxygen or causing phytotoxicity to plants due to insufficient biodegradation of organic matter.

2.3 Goat dung

Ojeniyi and Adegboyeaga (2003) found that goat manure significantly increased growth and yield of okra, amaranthus, celosia and maize in southwest of Nigeria. Besides, Samuel et al. (2003) found that goat dung increased the soil pH, nitrogen and crop yield in southeast of Nigeria. Based on studies by Awodun, Omonijo and Ojeniyi (2007), they pointed out that goat dung is high in organic matter and have more N than K, Ca and Mg. The low organic matter and available phosphorous and acidic nature of soils is expected to benefit from application of goat dung. They also mentioned that goat dung significantly increased the availability of nutrients in soil, nutrient status, growth and yield of pepper. However, the goat dung applied at 10 t ha^{-1} was most effective among the levels investigated which are 0, 2.5, 5.0 and 7.5 t ha^{-1}. To conclude, goat dung is an effective source of N, P, K, Ca and Mg and organic matter for pepper production.

Mupondi, Mnkeni and Brutch (2006) stated that goat dung and sewage sludge had high N contents, indicating that they both could be used to reduce the C/N ratio of pine bark. The pH of goat dung was greater than 7 which indicating a possible liming effect when mixed with pine bark. The pH of sewage sludge was low which is below 6 indicating that its mixture with pine bark is still acidic. Goat dung also had higher electrical conductivity representing that goat dung had more soluble salts. They also pointed out that goat dung have higher levels of total K, Ca, and Mg than sewage sludge. This could be attributed to the latter's treatment process which encourages leaching of soluble salts.

2.4 Effect of organic and inorganic fertilizers on leafy vegetables

2.4.1 Physiological growth response

Organic and inorganic fertilizers are major suppliers of primary macronutrients such as nitrogen (N), phosphorous (P) and potassium (K). These primary macronutrients are required in maximum quantities by plants. Among all the essential nutrients, nitrogen is the nutrient that most often restricts the plants and is required in the highest quantities for the plant growth. The nitrogen that available for plant uptake is in the form of ammonium NH_4 and nitrate NO_3. Nitrogen serves as a constituent of chlorophyll for photosynthesis to run smoothly. High photosynthesis activity when adequate nitrogen supply can cause vigorous vegetative growth with a dark green colour appearance of the plants (Miller & Donahue, 1990).

Munson et al. (1985) stated that phosphorous is the second most limiting nutrient in growth of plant. The total concentration of surface soil varies from 0.02% to 0.10% because the mineral phosphate form is not readily soluble for plants to absorb. The P was uptake by plants in the form of hydrogen phosphate (HPO_4) and dihydrogen phosphate (H_2PO_4). Phosphorous plays an important role in photosynthesis and protein makers. The effect of inadequate of P supplies will lead to low photosynthesis activities, low protein maker, low RNA synthesis and ultimately depressed the growth of plants. Subsequently, for potassium, it is important in plant growth and reproduction. It also plays a role in photosynthesis, carbohydrate transport, formations of protein and regulation of plant stomata.

In addition, Schlect, Buerkert, Tielkes, and Bationo (2006) stated that the organic matter from organic fertilizers also supplies carbon into the soil and provides substrates for microbial growth. Decomposition activity in soil increases when soil microbial diversification increases. On the other hand, substantial quantities of N, P, S and even smaller amount of micronutrient or trace elements are released into the soil nutrient bank. Various nutrients are then converted to the available forms by the microbes for the use of plants. For example, some organic matter produced during mineralization can act as chelates that aid in the absorption of iron and other micronutrients to overcome the shortage of micronutrients in the soil.

Agbede, Ojeniyi and Adeyemo (2008) reported that organic fertilizer can improves the organic content of the soil and gradually improves the physical properties of soil such as soil structure, bulk density of soil and aeration. According to Mbatha (2008), good soil aeration is better for roots to grow deeper, ensuring a strong stalk or stems and higher plants, especially in sandy soils or high nutrient areas and high percentage of clay soil. For example, the addition of manure can stimulate the growth of carrot roots to a depth of 10cm. The roots that grow to deeper layers of soil are allowing plants to extract more nutrients and water. Plant growth rates such as height, stem diameter, leaf number and leaf area also can enhance. In addition, humus derived from organic fertilizer or manure is also a very good substrate for plant growth (Suge, Omunyin & Omami, 2001).

Furthermore, studies show that the early stages of growing vegetables under organic fertilizer compared to those receiving inorganic fertilizers are much slower (Mbatha, 2008). This could be attributed to lower levels of nitrogen and phosphorus for early-stage plants in organic fertilizers. Conversion of organic form to an available N is quite slowly within the first 4 weeks following the addition of organic fertilizer. Approximately 60% of N is only available within the first 6 weeks in the soil and the remaining 40% of N is available on the next crop or season (McCall, 1980). Likewise, phosphorus and other plant nutrients may not be available until next season. In the first season, there is only potassium that is available in the soil. So that, timing for application of organic fertilizer is important. Healthy vegetable growth can be recompensed by organic fertilizers with the help of soil microorganisms in producing plant growth regulators which are essential for plant vegetative growth and photosynthesis activities (Arisha, Gad & Younes, 2003).

2.4.2 Yield

Various studies have compared the yields of organic fertilized plants with inorganic fertilized plants. Firstly, Haraldsen et al. (2000) have study the positive effects of using inorganic fertilizers on crop yields and yield improvements. The vegetables that have been treated with inorganic fertilizers such as cucumber, tomato and cabbage are obtaining higher yields than organic fertilizer. However, study done by Mbatha (2008) show that the organic fertilized leafy vegetables like lettuce and amaranthus have more dry mass than the inorganically fertilized. The slow release of nutrients from organic fertilizer into the soil can reduce loss of nutrients due to run off, leaching and volatilization (Rauton, 2007).

Takebe et al. (1995) reported that the increase in leaf dry weight was due to the combination of nitrogen with plant material produced during photosynthesis such as glucose, ascorbic acid, amino acids and proteins. As the leaves are the main organ of photosynthesis, any increase in the number of leaves and leaves area by organic and inorganic fertilizers will increase the rate of plant photosynthesis as lighter is intercepted. Therefore, high leaf dry weight will be obtained. Subsequently, better plant growth by fertilizers has always led to improved carbohydrate enhancement that improves crop yields and their component quality (Mbatha, 2008).

The use of organic fertilizers can meet crop nutrient requirement if used regularly (FAO, 2008). In dry areas containing some heavy soils, the soil structure and fertility will improve if it continues to be served with chicken manure. Therefore, higher yields or crops will be produced. In addition, the time of application for fertilizers needs to be considered in order for organic-fertilized plants to produce higher yields. Otherwise, the result of organically treated plants may be deteriorated due to slower nutrient release and nutrient absorption (Warman, 2000).

2.4.3 Nutritional quality

Malaysia has to face the challenges of trade regulation and requirements from the World Trade Organization (WTO), where only the high quality of vegetables and fruits can penetrate the foreign markets such as Europe and developed countries. In the domestic agricultural food market, the demand for high quality vegetables has increased as more people are able to afford high quality foods. Thus, producing vegetables and fruits with good nutritional quality is concerned by agriculturists (Tey et al., 2009).

Hassan et al., (2012) said that despite plant genetic makeup, maturity and climatic conditions are play more important role in the composition of plant nutrients. Next, Liu and Li (2003) have shown that organic vegetables produce high concentrations of vitamins A, B1 (thiamin), B2, B12 (cynocobalamin), C, E, soluble proteins, carbohydrates, total sugar and mineral compounds which are Ca, K, Mg, S and Na when compared to inorganic fertilized vegetables (Liu and Li, 2003). Moreover, the crops that are organically managed usually have higher vitamin C than inorganic treatments. This is because when the plants are exposed to more nitrogen, the production of protein will increase and the synthesis of carbohydrates will decrease. Vitamin C levels are also minimized because it is synthesized from carbohydrates. In organically managed soils, the plants are exposed to lower amounts of nitrogen and organic crops would be expected to maintain a higher vitamin C as well (Shree, Singh & Kumar, 2014).

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

The material were used in this study were vegetables waste which collected from the Pasar Besar Jeli at Jeli, Kelantan, Malaysia. Besides, goat dung was collected from Agro Park in Universiti Malaysia Kelantan (UMK), Jeli Campus. Other than that, the seeds of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*) were purchased from nearby market of Lacjaya Sdn. Bhd at Ayer Lanas, Kelantan, Malaysia. The bins for compost process also purchased from the nearby market which is Pasaraya Pantai Timur Sdn. Bhd at Tanah Merah, Kelantan, Malaysia. The other tools needed are polybag, spad meter, weighing scale, ruler and garden scoop.

3.2 Method

3.2.1 Preparation of compost

The vegetables waste such as damaged bean sprouts, brinjal, leeks, mustard green and goat dung were weighed, mixed and placed in bins at the size of 46 cm (length) x 41 cm (width) with covers. The vegetables wastes were cut into pieces to ease the composting process. The ratio for composting vegetables waste and goat dung is 1:1 which are 3 kg of vegetables waste and 3 kg of goat dung. The mixtures were watered up to 60% of humidity. The materials in bins need to turnover for every 3 days in the initial stages and weekly in the later stages. This will be enabled the homogenization of the materials, enhancing aeration and temperature. The composting process is in a 40 to 60 days to allow it being mature compost.

3.2.2 Seedling growth test

The experiments were carried out in the nursery of University Malaysia Kelantan, Jeli Campus (5.7445^{o}N, 101.8642^{o}E). The seeds of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*) were allowed to germinate in the seedling tray that was filled with peat moss as a growing medium. Two seeds were planted for each hole. After 2 weeks of germination, the seedlings were thinned out to one plant and transferred into the polybag with 16cm of diameter that formerly were filled with top soil as a growing medium. 54 polybags were used to investigate the performances growth of choy sum and pak choi. Both leafy vegetables were grown and watered twice a day or when necessary to maintain the soil moisture. Weed control were accomplished manually. The treatments were applied to the vegetables as following the table below:

Table 1: Types of treatments and their rates of application (Awodun, Omonijo & Ojeniyi, 2007)

Treatments	Rates of application (g per plant/ kg per hectare)
Control	0 g/plant =0 kg/hectare
Commercial NPK fertilizer	0.5 g/plant =250 kg/hectare
Compost	30g/plant =15 000 kg/hectare

3.2.3 Measurement of growth parameters

All of parameters were measured after 1 month of the treatment being applied to the vegetables. The vegetables height and root length were measured by using the ruler. The shoot fresh weight was measured by using weighing scale while chlorophyll content of leaves was measured by using spad meter. All measurements were done in three replicates and the mean were calculated.

3.2.4 Statistical analysis

Each experiment was arranged as a completely randomized design with three replications. The results obtained were statistically elaborated further by using SPSS statistics V21. Tukey test (HSD) was run to investigate the differences between the groups in which all pairs of means were compared using one-way ANOVA. When ($P \leq 0.05$), the data of the study is consider significantly different (Godlewska, Michalak, Tuhy & Chojnacka, 2017).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Effect of compost and commercial NPK fertilizer on plant height of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*)

The figure 4.1 showed the plant height against the treatments applied on the choy sum and pak choi is having a similar trend. It was found that there are significant differences between control and commercial NPK fertilizer. There are also having significant differences between control and compost on the plant height of choy sum and pak choi (Appendix A.1 and Appendix A.2). However, there are no significant increased between commercial NPK fertilizer and compost. The application of compost treatment on choy sum and pak choi showed the highest plant height which gives an increase of 37.6% and 47.2%, respectively, while for commercial NPK fertilizer is increase 25% and 40.6%. The maximum height plant was recorded with 86.5 cm for choy sum and 180.8 cm for pak choi.

This study has similar trend with a study conducted by Jose, Marciza, John, Douglas, Jose and Adriano (2017), where the used of cattle manure can increase the height of lettuce (*Lactuca sativa*) from 0 to 12%, arugula (*Eruca sativa*), from 41 to 85% and for common chicory (*Cichorium intybus*), it increase from 0 to 36%. However, in another study conducted by Muhammad, Jayanta and Byeon (2018), shows that the highest of plant height for *Moringa oleifera* is from NPK (12:17:17) fertilizer treatment compared to the compost by using rate of application at 120 kg ha^{-1}.

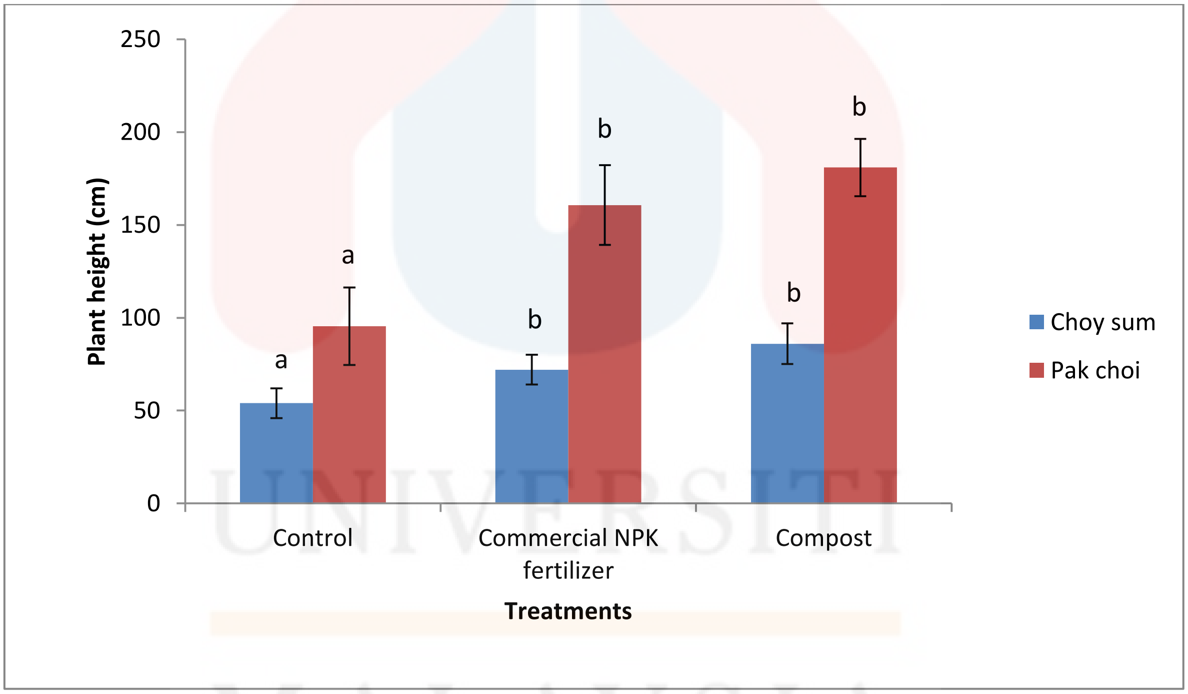

Figure 4.1: The effect of compost and commercial NPK fertilizer on plant height of choy sum and pak choi. Vertical bars represent standard deviation (SD) of the mean.

4.2 Effect of compost and commercial NPK fertilizer on root length of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*)

The above figure 4.2 presented the data regarding the growth parameters root length of choy sum and pak choi. It was found that the mean of root length for both plants was not much influence by the application of treatments. This is because there is no significant differences in values of root length despite the plants were applied with different treatments (Appendix B.1 and Appendix B.2). Even so, compost treatment on choy sum was the highest which is 85.5cm compared to other treatment which is commercial NPK fertilizer is 70.8cm while the control has the least root length measurement (62.3cm). Mean's control for pak choi was the lowest which is 94.8cm compared to both treatments of commercial NPK fertilizer and compost which is 114.5 and 112.5, respectively. The application of compost on choy sum gives increase 27.5% of root length while 15.7% increase on pak choi's root length.

A study done by Kalpana, Sai and Anitha (2011) found that the application of vegetables waste mixed with organisms such as *Azotobacter* as organic compost has shown better rate of germination and growth for *Cicer arietinum* (chick pea) with the highest values of root lengths was observed. Besides, Islam, Ahmed, Mahmud, Tusher and Khanom (2012) studied that the compost was the highest average of root length for lettuce (*Lactuca sativa*), because it ensures favorable condition for the growth of lettuce. In addition, based on study conducted by Si et al. (2016), all fertilization treatments which are manure and manure combined with commercial NPK fertilizer increased the root length of yellow poplar (*Liriodendron tulipifera*) by 21%.

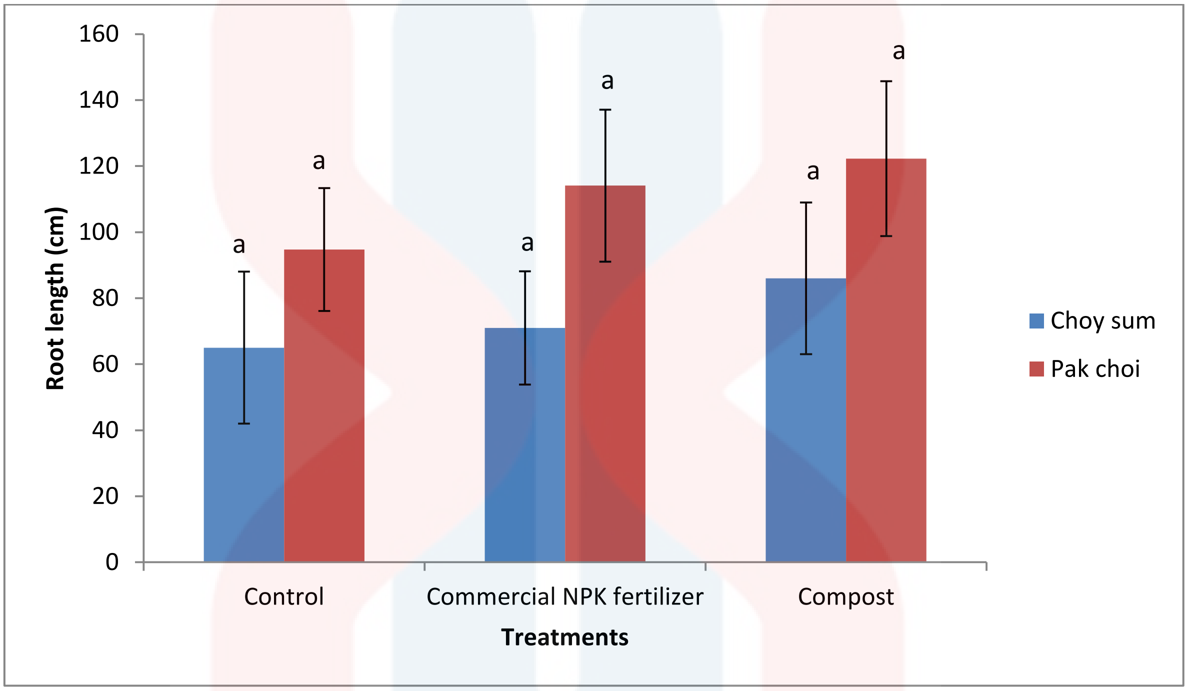

Figure 4.2: The effect of compost and commercial NPK fertilizer on root length of choy sum and pak choi. Vertical bars represent standard deviation (SD) of the mean.

4.3 Effect of compost and commercial NPK fertilizer on plant weight of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*)

Plant weight of choy sum and pak choi as affected by compost and commercial NPK fertilizer are shown in Figure 4.3. The result showed that the compost treatment have significant increase in plant weight as compared to control for both vegetables (Appendix C.1 and Appendix C.2). Similar trend was also observed when the tested plants were treated with commercial NPK fertilizer. The weight for choy sum on compost treatment is gives an increase of 50% (43.3g) while 33.2% (32.5g) for commercial NPK fertilizer. For pak choi, there were significant differences ($P < 0.05$) in plant weight values obtained from the treatment of compost and commercial NPK fertilizer (Appendix C.2). The application of compost gives an increase of 87% weight with the highest value of 466.7g. The mean value for commercial NPK fertilizer is 316.7g which increase 81% of pak choi's weight.

Based on a study conducted by Abou-El-Hassan and Desoky (2013), compost are successfully performed by adding 1.670 kg/m^2 and 2.085 kg/m^2 compost for lettuce (*Lactuca sativa*) cultivation to get high yield and quality. This study stated that the used of compost as organic fertilizer has many advantages such as conditioning effect, raising cation exchange capacity, increases water retention, greater stability temperature and improves nutrient availability.

Similar with a study conducted by Islam, Ahmed, Mahmud, Tusher and Khanom (2012) who stated that the growth of lettuce (*Latuca sativa*) was highest by using compost at 35 tons/ha. Besides, study conducted by Sanni (2016) found that the used of cow dung had maximum yield of *Amaranthus hybridus* which is 82.02 kg ha^{-1}, followed by NPK 15-15-15 with a yield of 63.0kg ha^{-1} and *A. hybridus* grown in control had the minimum yield which is 28.48 kg ha^{-1}.

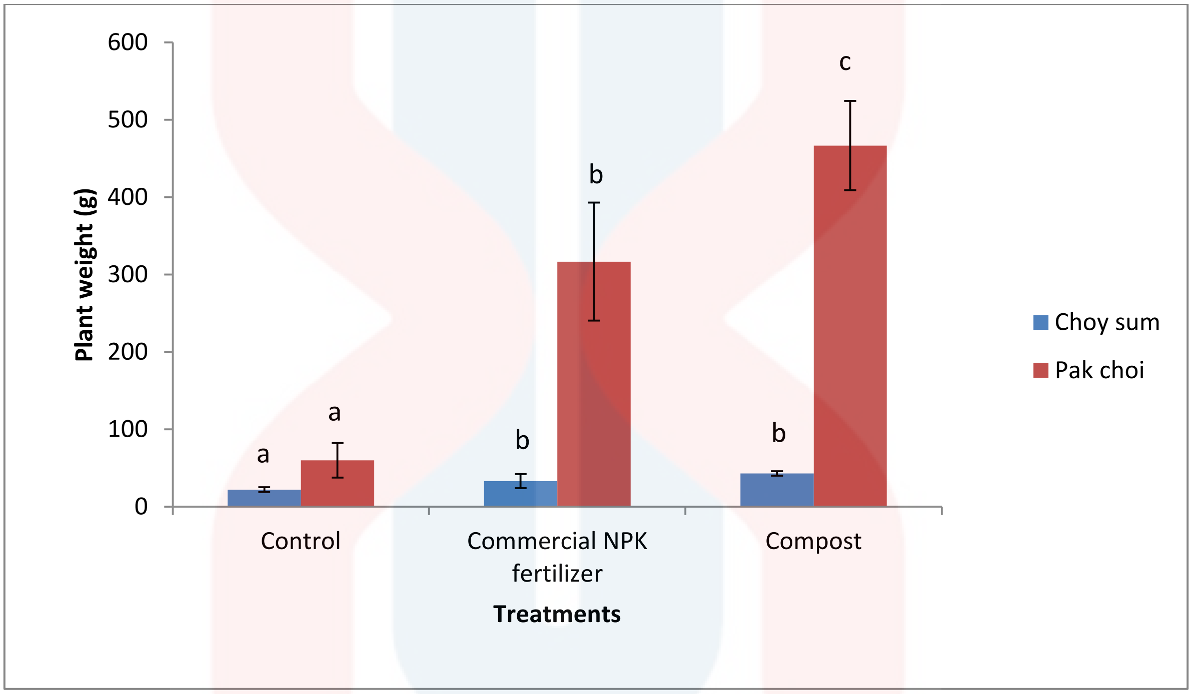

Figure 4.3: The effect of compost and commercial NPK fertilizer on weight plant of choy sum and pak choi. Vertical bars represent standard deviation (SD) of the mean.

4.4 Effect of compost and commercial NPK fertilizer on chlorophyll content of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*)

Figure 4.4 showed that the chlorophyll content in the choy sum's leaves and pak choi's leaves against the treatments applied. It was found that the mean chlorophyll content of choy sum and pak choi treated with compost had significant increased compared to control (Appendix D.1 and Appendix D.2). However, there are no significant increased between commercial NPK fertilizer and compost. Based on the mean of chlorophyll content of choy sum for compost treatment, there are increment values from 99.7nm to 125.3nm with the increase of 20.4% compared to 16.3% increment for commercial NPK fertilizer which is 99.7nm to 119.1nm. Meanwhile, the effect of compost on chlorophyll content of pak choi show increasing of 13% with the value of 114nm compared to 11% of commercial NPK fertilizer with the value of 110.7nm.

Chlorophyll is abundant in leaf and other plant parts with green characteristic and plays a role in the process of plant photosynthesis. Chlorophyll is in chloroplasts, where photosynthesis process was occurs. The pigments found in the tilakoid membrane will absorb light from sun or other sources, and then convert light energy into chemical energy in the form of adenosine triphosphate (ATP). The more chlorophyll content in leaf will result in higher photosynthesis process (Fahrudin, 2009). In recent studies, chlorophyll content in spinach is higher but it decreases with the use of percentage of green compost. The lowest chlorophyll content was recorded in plant growth with 50% of compost whereas the 25% of compost have same result as plant grown without compost (Tavarini, Cardelli, Saviozzi, Degl'Innocenti & Gauidi, 2011). In contrast, study done by Doncean, Sumalan and Sumalan (2013) show that of chlorophyll content of tomato (*Lycopersicum esculentum L.*) seedlings had the highest value for the treatment of 100% compost compared to other mixtures of compost.

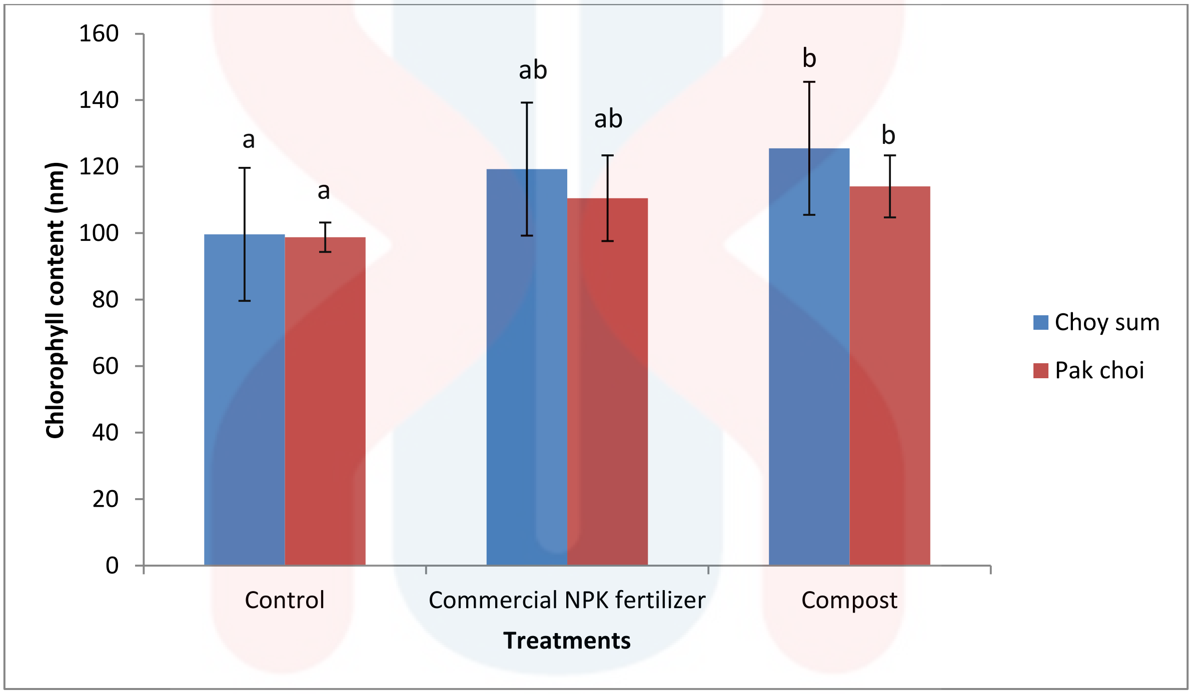

Figure 4.4: The effect of compost and commercial NPK fertilizer on chlorophyll content of choy sum and pak choi. Vertical bars represent standard deviation (SD) of the mean.

CHAPTER 5

5.1 Conclusion

The result from this study showed the stimulating effect from the treatment of organic compost to choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*). The parameters of plant height, plant weight and chlorophyll content for both leafy vegetables are significantly increase ($P \leq 0.05$) while the root length shows insignificant results ($P \leq 0.05$) compared to control. Thus, this study proved that the maximum growth of choy sum (*Brassica rapa var parachinensis*) and pak choi (*Brassica rapa var chinensis*) were successfully achieved when the plants were supplemented with organic compost which is vegetables waste mixed with goat dung. Even though commercial NPK fertilizer shows similar effect to organic compost, the organic compost exhibit more higher value in increased the growth of both vegetables. To conclude, the overall results of the study indicate that the compost of vegetables waste mixed with goat dung can be applied and used to ensure the more healthy and vigorous growth of mustard green plants.

5.2 Suggestions and recommendations

It is practically recommended that for better growth performances of choy sum and pak choi such as plant height, root length, weight plant and chlorophyll content, the application of compost at the rate of 15000 kg ha^{-1} is appropriate. However, the exact mechanism as to how the compost acts to improve growth and development of plants is still unclear. Hence, further studies of the vegetables waste mixed with goat dung as organic compost should be carried out in the future by characterize the compost and soil analysis should also be determined.

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APPENDICES

APPENDIX A

Table A.1: Homogenous subsets for plant height for choy sum

Effect of compost and commercial NPK fertilizer on plant height choy sum

Tukey HSD

Treatment	N	Subset for alpha = 0.05	
		1	2
Control	3	54.0000	
Commercial NPK fertilizer	6		72.0000
Compost	4		86.5000
Sig.		1.000	.089

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.000.

Table A.2: Homogenous subsets for plant height for Pak choi

Effect of compost and commercial NPK fertilizer on plant height Pak choi

Tukey HSD

Treatment	N	Subset for alpha = 0.05	
		1	2
Control	6	95.5000	
Commercial NPK fertilizer	4		160.7500
Compost	6		180.8333
Sig.		1.000	.251

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 5.143.

APPENDIX B

Table B.1: Homogenous subsets for root length for choy sum

Effect of compost and commercial NPK fertilizer on root length choy sum

Tukey HSD

Treatment	N	Subset for alpha = 0.05
		1
Control	4	65.2500
Commercial NPK fertilizer	5	70.8000
Compost	6	85.5000
Sig.		.332

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.865.

Table B.2: Homogenous subsets for root length for Pak choi

Effect of compost and commercial NPK fertilizer on root length Pak choi

Tukey HSD

Treatment	N	Subset for alpha = 0.05
		1
Control	5	94.8000
Commercial NPK fertilizer	4	114.5000
Compost	6	122.5000
Sig.		.160

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.865.

APPENDIX C

Table C.1: Homogenous subsets for plant weight for choy sum

Effect of compost and commercial NPK fertilizer on plant weight choy sum

Tukey HSD

Treatment	N	Subset for alpha = 0.05	
		1	2
Control	3	21.6667	
Commercial NPK fertilizer	4	32.5000	32.5000
Compost	3		43.3333
Sig.		.124	.124

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.273.

Table C.2: Homogenous subsets for plant weight for Pak choi

Effect of compost and commercial NPK fertilizer on plant weight for Pak choi

Tukey HSD

Treatment	N	Subset for alpha = 0.05		
		1	2	3
Control	5	60.0000		
Commercial NPK fertilizer	3		316.6667	
Compost	3			466.6667
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.462.

APPENDIX D

Table D.1: Homogenous subsets for chlorophyll content for choy sum

Effect of compost and commercial NPK fertilizer on chlorophyll content choy sum

Tukey HSD

Treatment	N	Subset for alpha = 0.05	
		1	2
Control	6	99.6667	
Commercial NPK fertilizer	7	119.1429	119.1429
Compost	6		125.3333
Sig.		.061	.717

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 6.300.

Table D.2: Homogenous subsets for chlorophyll content for Pak choi

Effect of compost and commercial NPK fertilizer on chlorophyll content Pak choi

Tukey HSD

Treatment	N	Subset for alpha = 0.05	
		1	2
Control	6	98.8333	
Commercial NPK fertilizer	6	110.6667	110.6667
Compost	6		114.0000
Sig.		.118	.823

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 6.000.