Vermiwash as a soil supplement to improve the growth of leafy vegetable, pak choi (*Brassica rapa* var *chinensis*).

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A thesis submitted in fulfilment of the requirement for the degree of bachelor of applied science (agrotechnology) with honours

Faculty of Agro Based Industry

Universiti Malaysia Kelantan

2018

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.

_____

Student

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Date

I certify that the report of this final year project entitled "Vermiwash as a soil supplement to improve the growth of pak choi (*Brassica rapa* var *chinensis*)" by Raja Nur Julaizzah Binti Raja Ali, matric number F15A0198 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Agriculture Technology) with Honors, Faculty of Agro-Based Industry, Universiti Malaysia Kelantan.

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ACKNOWLEDGEMENT

Alhamdulillah, first of all, I would like to thank that incomparable power the Almighty God for getting me this far to finish this project with effectively and successfully. The Almighty God who is clearly the one has constantly guided me to work on the right way of life. Without HIM, fulfilment of this final year project is dicey.

Besides, by all means I would like to express my sincere gratitude and thousand appreciations to my supervisor Dr. Norhafizah Binti Md. Zain, for all the patience, support, motivation, supervision, cooperation and immense knowledge for making this final year project run easily. Her guidance and kindness help me to complete this thesis will be remembered all the time.

Furthermore, my deepest grateful to my family for their overwhelming support throughout my final year completion. To wrap things up, I might want to thank my friends Nurshamimi Binti Zaini, Noor Iffa Hanis Binti Zakaria, and Nur Aqazah Binti Bungsu because they loaned me with their constant support, consolation, and guidance during the whole time of completing the project.

I have no significant words to express my much obliged, yet my heart is still brimming with the favors got from everybody. Finally, I would like to say thanks for those that being involved directly or indirectly in finishing my final year project. May Allah bless them in this life and the life of here-after *In sha Allah*.

Vermiwash as a soil supplement to improve the growth of leafy vegetable, pak choi *(Brassica rapa* var *chinensis*)

ABSTRACT

Currently, the use of chemical fertilizer in agriculture has become widespread and cause many negative effects on humans and environment. An experiment was carried out at the nursery of University Malaysia Kelantan (UMK) Jeli Campus to investigate the effect of vermiwash as a soil supplement on the growth of pak choi (*Brassica rapa* var *chinensis*) along with commercial NPK fertilizer. B. *rapa* was chosen due to it fast growth with various nutrient. The treatments: T_1 (0 g/ha control), T_2 (0.4 g/ha of NPK) and T_3 (0.0003 g/ha of vermiwash) were applied on the soil surface when the tested plant at age of 2 weeks and 4 weeks. After 1 month of treatment application, vermiwash application showed significance increased on the growth of *B. rapa* in term of plant height, plant weight and root length with 527 cm, 385 g and 277 cm, respectively compared to commercial NPK fertilizer with 253 cm, 140 g, 231 cm and control. However, there were no significant increased on the chlorophyll content. It can be concluded that the growth of *B. rapa* showed stimulation when applied using vermiwash. Hence, vermiwash proves to be an effective fertilizer which encourage the growth of plants and may be a potential source of plant nutrient for sustainable crop production.

Keywords: Vermiwash, organic fertilizer, earthworm, *Brassica rapa* var *chinensis*.

Vermiwash sebagai pelengkap tanah untuk meningkatkan pertumbuhan sayuran berdaun, pak choi (*Brassica rapa* var *chinensis*)

ABSTRAK

Pada masa ini, pemggunaan baja kimia pada pertanian makin berleluasa dan menyebabkan banyak kesan buruk kepada manusia dan persekitaran. Eksperimen dijalankan di tapak semaian Universiti Malaysia Kelantan (UMK) Kampus Jeli untuk mengkaji kesan vermiwash sebagai tambahan kepada tanah untuk pertumbuhan pak choi (*Brassica rapa* var *chinensis*) bersama dengan baja NPK komersial. B. *rapa* dipilih kerana tumbesarannya yang pantas bersama pelbagai nutrient. Rawatan: T_1 (0 g/ha kawalan), T_2 (0.4 g/ha NPK) dan T_3 (0.0003 g/ha vermiwash) dirawat pada permukaan tanah apabila tanaman yang diuji pada umur 2 minggu dan 4 minggu. Selepas 1 bulan pengaplikasian rawatan, penggunaan vermiwash menunjukkan peningkatan yang signifikan terhadap pertumbuhan *B. rapa* dari segi ketinggian tumbuhan, berat tumbuhan dan panjang akar masing-masing dengan 527 cm, 57 g dan 277 cm, dibandingkan dengan baja NPK komersial dan kawalan. Walau bagaimanapun, tiada peningkatan yang signifikan terhadap kandungan klorofil. Dapat disimpulkan bahawa pertumbuhan *B. rapa* menunjukkan rangsangan apabila menggunakan vermiwash. Oleh itu, vermiwash terbukti menjadi baja yang berkesan yang menggalakkan pertumbuhan tanaman dan mungkin menjadi sumber nutrien tumbuhan yang berpotensi untuk pengeluaran tanaman yang mampan.

Kata kunci: Vermiwash, baja organik, cacing tanah, *Brassica rapa* var *chinensis*.

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G	-	Gram
Cm	-	Centimetre
Nm	-	Nanometre
Ml	-	Millilitre
Ha	-	Hectare
L	-	Litre
%	-	Percentage
/	-	Per
°C	-	Degree Celsius
CRD	-	Completely randomized design
ANOVA	-	Analysis of variance
SPSS	-	Statistical Product and Service Solution
HSD	-	Honest Significance Difference
Df	-	Degree of freedom

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Nowadays, there are increasing in use of chemical fertilizer and pesticides for their crops which cause contamination of food materials and lead to health problems to customers and decreased soil fertility. Organic farming practice are recommended because by apply organic farming, the environment can be protect, maintain long-term soil fertility and biological diversity within the system and more (Hugh, 2009). Organic farming is a strategy for crop and livestock production that includes significantly more than picking not to utilize pesticides, fertilizers, genetically changed living beings, anti-toxins and development hormones (Hugh, 2009).

In organic farming, we are usually use organic fertilizer which known as slow release fertilizer. Organic fertilizers are fertilizers that produced through animal based materials, plants and minerals. But in general the largest organic fertilizer production between these materials is from mineral substances such as limestone, phosphate rock and ammonia (Carlz, 2014). Organic matter that present in organic fertilizer will give beneficial effects on physical, chemical and biological characteristics of soil such as improve soil structure, soil moisture, water holding capacity, water infiltration and more (Sundararasu, 2017).

Earthworm assumes an indispensable part in plant growth and productivity. The role of earthworm in their soil formation and soil fertility is well documented and recognized due to collection of excretory and secretory products of earthworms that come along with micronutrients, macronutrients and soil organic which is good for plants (Sundararasu & Jeyasankar, 2014). Vermiwash is a liquid fertilizer which becoming popular as organic fertilizer and it is collected of water after it pass through a column of worm activation. Vermiwash contain an enzyme which is secretion of earthworm that would encourage the development and yield of agricultural crops and evolve resistance in crops (Sundararasu, 2017).

Pak choi is the vegetable that belong to Brassicaceae family. The scientific name of pak choi is *Brassica rapa* var *chinensis*. Cultivation of *Brassica rapa* var *chinensis* is popular in China and other parts of Asia such as Malaysia, Japan, Indonesia and also Philippines. Besides, *B. rapa* is one of the easier vegetables that easy to crossbreed and today there are many varieties of *B. rapa* in variant of shapes, size and colours which is white, green, purple and red. However, many people prefer to consume the green varieties because it tastes better than others.

Besides, in order to increase the production yields of *Brassica,* high amount of nitrogen (N) fertilizer are applied. However, the availability of N may vary depending on fertilizer type such as organic fertilizer and inorganic fertilizer. Deficiency of nitrogen may lead to reduction in growth and yield. Yeshiwas (2017) noticed a significant increase in fresh weight (0.114 kg/plant) of *Brassica oleracea* by application of 150kg N/ha, while 0.442 kg/plant noticed from 0 kg N/ha.

Ahmed, Ahmed, Faridullah & Hussain, (2003) reported that, in *Brassica caulorapa* L. NPK fertilizer at the rate 160-120-160 kg/ha is utilized by the plant at maximum rate. The growth and yields were highest at this level. Their result shows the maximum tuber weight (430.80 g), number leaves per plant (14.38) and tuber yield is 25850 kg/ha.

1.2 Hypothesis

$H_{0:}$ Vermiwash would not significantly increase the growth performance of *B. rapa* as compared to NPK fertilizer.

$H_{1:}$ Vermiwash significantly increase the growth performance of *B. rapa* as compared to NPK fertilizer.

1.3 Problem Statement

Nowadays, people has overuse the chemical fertilizer which can cause the hardened the soil, decrease the soil fertility, polluted air and water, release greenhouse gases and can make health issues to human health and environment as well. Continuous use of these chemical fertilizers can decrease the essential soil nutrients and minerals that are naturally found in soil. Besides, use of commercial NPK fertilizer only replenish nitrogen, potassium and phosphorous instead of other soil nutrient. Overuse of specific fertilizer also can cause imbalance in soil nutrient which can lead to soil degradation and loss of equilibrium of stable soil. Therefore, these problems can be reducing by using vermiwash as replacement and supplement because vermiwash provide nutrients effectively and quickly to the plants (Fathima & Sekar, 2014).

1.4 Objective

1. To determine effects of vermiwash application on the growth performance of *B. rapa.*

1.5 Significance of Study

There is no doubt modern agriculture which based on organic matter play a major role in producing a good quality and higher production of crops. Nowadays, people are seeking for something that could be cheaper and eco-friendly to reduce the investment that they made for fertilizer along with the maintaining of soil fertility. This study focuses on the effect of vermiwash on growth performance of *B. rapa*. Hence, this study is important to investigate the effectiveness of vermiwash as soil supplement which can improve the growth of *B. rapa* and lead to reduce the use of chemical fertilizer on the crops.

CHAPTER 2

LITERATURE REVIEW

2.1 Vermiwash

Vermiwash is a liquid which collected by passing water among a path of soil that containing active earthworm and compost and have combination of earthworm mucous discharges, microorganism, nutrient and plant growth that can increase the development of the plant. Besides, it is also as biotic aqua fertilizer because people can apply it as pesticides and it also contain crucial nutrient for plants (Zarei, Jahandideh, & Ameneh, 2018). Furthermore, earthworm will secrete leachate that rich in nutrient. The secretion is a chemical that break down the organic matter into sustainable nutrition which can improves soil texture, structure, aeration and promoting good plant growth.

Besides, vermiwash also can stimulate the growth and yield of crops and can develop resistance to disease of plants. Since vermiwash have soluble plant nutrient and mucus from earthworm and microbes, the effectiveness of vermiwash on plants cannot be denied. Usually, people will apply vermiwash by spray in the leaf surface of the plants which can increase the uptake of nutrient to the plants through stomata openings, leaves and stems. Other than that, plant also can absorb foliar fertilizer faster than soil applied fertilizer and can encourage plant's growth such as rapid growth during seedling emergence, flowering and fruiting.

There is several advantages using vermiwash since the main character to gain the leachate is earthworm because earthworm need temperature range from 50 ºC to 80 ºC in order to stay alive. The moisture and ventilation need to be observed in order to prevent any obstacles. The application at right level of air and moisture in the system is important in order to prevent earthworm got killed due to improper ventilation or excess moisture (Emily, 2015). Earthworms require a controlled eating routine to survive and create humus. People need to avoid placing inorganic materials in the container because earthworm unable to break down that materials (Emily, 2015).

Besides, earthworms also have a dark brown coloured when they become adult and growth in 5-7 cm length, 3-5 mm in width and 500-600 mg in weights. Earthworm species of *Eisenia fetida* used to manage solid wastes and can degrade especially materials that rich in cellulose. Besides, earthworm also grouped as phytophagous because they consume plant materials as main food. There are also studies which found out that earthworm effectively bio-accumulated of biodegrade of organic and inorganic chemical such as heavy metals that can be found in the soil which is inhabited by earthworm.

2.1.1 Taxonomy of Earthworm *Eisenia fetida*

The orderly classification of the species as follows:

Kingdom Animalia

Subkingdom Bilateria

Phylum Annelida

Class Oligochaeta

Order Haplotaxia

Family Lumbricidae

Genus Eisenia Malm, 1877

Species *Eisenia fetida*– red wiggler

Figure 2.1.1: Taxonomy of earthworm (Juárez, Fuente, & Paulín, 2011)

2.1.2 Effect of earthworm *Eisenia fetida* in vermiwash on others plant

Moreover, according to study done by Hatti, Londonkar, Patil, Gangawane and Patil (2010), the root and shoot length of *Vigna mungo* shows an increase non-significantly when applied with vermiwash on 20 and 40 days. The number of leaves and twig increase after sprayed with vermiwash and the flower, pods and grains of *V. Mungo* also growth rapidly after applied with vermiwash on 40 days.

Besides, they also applied vermiwash treatment on *Vigna radiate* for 20 days and 40 days. However, there were no significant different of *V. radiate* in term of root and shoot length for 20 days but *V. radiate* show significant for root and shoot length when they applied the vermiwash on 40 days. The number of twigs, flower, leaves, pods and grains also increases significantly for both 20 days and 40 days.

Other than that, vermiwash also increase the root and shoot length of *Sesamum indicum* when sprayed with vermiwash for 20 days and 40 days. The twigs, number of leaves and biomass of *S. indicum* also increase compared to control for both 20 days and 40 days. However, the flower of *S. indicum* only appeared when been applied with vermiwash on 40 days. It is interesting to know that vermiwash also can enhance the growth of origin bud and flowers, pods and grains.

2.2 Pak Choi (*Brassica rapa* var *chinensis*)

Pak choi or scientific name is *Brassica rapa* var *chinensis* and these crops is one of the mustard family that also known as bok choy, Chinese celery and celery cabbage. *B rapa* were first cultivated in China during 15th Century and widely grown in others Southeast Asia such and to a lesser extent in others part of the world. Besides, *B. rapa* is one of the loose leaf varieties that available in Asia. It is fast growing because it can be harvest after 30 days as soon as it has usable leaves.

Furthermore, the seed of *B. rapa* is small and black seeds. Soil pH need to be in range 5.5 to 7.7. Transplant usually can be started four until five weeks before field planting and depend on the environment and maturity of *B. rapa.*

The most interesting is *B. rapa* can be consumed from the stage of transplant but it is really recommended to harvest when *B. rapa* reach the mature stage (Eryilmaz, 2016). Furthermore, according to Acikgoz, (2016), the crisp leaves and thick petioles of *B. rapa* have a bitter taste that is suitable as boiled vegetable. The entire *Brassica* plant is edible and can absorb other flavours that make it all around versatile vegetable.

Moreover, *B. rapa* contain high water content, protein, carbohydrate, fiber, mineral, vitamin and also low in calories and very suitable for healthful diet. *B. rapa* also very suitable for consumption especially for cancer patients because it is contains folate that can increase production and repair of DNA in order to prevent cancer cell from forming. Besides, *B. rapa* also contains selenium that helps to detoxify some cancer compound in body and decrease tumor rates (Ware, 2018).

Besides, *B. rapa* resists high temperature and can be grow in full sun or partial shade. It has a very small seeds. *B. rapa* needs to be sow directly into the row with suitable spacing between the plants and transplant to bed or polybag after 15 until 30 days after seeding. The spacing between plants depend on the varieties such as for the smallest varieties, the spacing is between 2.5 until 10 cm and for largest varieties, the spacing is 15 until 30 cm.

Then, *B. rapa* is a shallow-rooted crop that need frequent watering compared to other leafy vegetables. In addition, *B. rapa* also prefers temperature between 15 to 20 °C and will growth on well drained and fertile loamy soil. Irrigation should be applied early in the morning and evening. Other than that, *B. rapa* need to receive at least 1 inch of water weekly (irrigation or rainfall) for optimum yield and quality.

2.2.1 Taxonomy of Pak Choi (*Brassica rapa* var *chinensis*)

The orderly classification of the genes as follows:

Kingdom Plantae

Subkingdom Viridiplantae

Class Magnoliopsida

Order Brassicales

Family Brassicaceae

Genus *Brassica* L.

Figure 2.2.1: Taxonomy of *B. rapa* var *chinensis* (National Plant Germplasm System [NPGS], 2007).

2.2.2 Important Pak Choi (*Brassica rapa* var *chinensis*) In Market

Nowadays, *B. rapa* become one of the famous and leading vegetables in Southeast Asia, China and Japan which is been grown about 500 000 ha. Besides, *B. rapa* is common in market in tropica Africa. The yield of *B. rapa.* can reach until 30 to 50 t/ha from well grown crops. According to Hosnan Anim (2011), the area of *B. rapa* is about 2,300 hectares in 2010 which the production is 24 million metric tons. One of the countries in Malaysia that has higher production of *B. rapa* is Johor especially in Johor Bharu, Kota Tinggi, Kluang and Muar which is involve in agriculture of *B. rapa*

about 28% compared to other crops. Overall production of *B. rapa* in Malaysia is more than 190, 00 metric tons per year. The production of *B. rapa* always have a high demand in Philippines and the annual production of *B. rapa* was 25 500 t/ha until 3800 t/ha. Malaysia also exports about 2000 t/ha of *B. rapa* to Singapore.

2.2.3 Fertilizer Application for Cultivation of *Brassica rapa* var *chinensis*

Hill (1990) has reported that the addition of N will increase the yield of *B. rapa.* He applied nitrogenous fertilizer on different Chinese vegetables such as Kai Lan, Tsoi sum and Pak choi and all the vegetables shows an increasing in yield which is 400 kg/ha for Kai lan and 200 kg/ha for both Tsoi sum and Pak choi. Nitrogen is important for plants in order to support their vegetative growth and enhancing the chlorophyll production.

There is a study about the nutrient management for a leafy vegetable by Ian (2016) which is the suitable fertilizer is the one that have right dose of each nutrient that needed for plants and recommended dose for N is 370 kg/ha. Besides, macronutrient uptake for leafy vegetables higher for K, N, Ca, Mg and P. Amount N that need to be applied for *Brassica chinensis L.* is 40-115 kg/ha and Potassium (K) is 60-169 kg/ha. Other than that, Calcium (Ca) need to be applied on *Brassica chinensis L.* about 12-49 kg/ha and amount of Phosphorus (P) with Magnesium (Mg) should less than 16 kg/ha (Abdullah & Illani, 2015).

Furthermore, according to study by Lancaster R. (2016), recommended rate for *Brassica oleracea* var *botrytis* was 100 kg/ha to 120 kg/ha of phosphorus fertilizer as pre-plant fertilizer which give an optimum yield of the plants. Besides, there was also trial of rate on *B.* oleracea var *botrytis* which is five rates with ranging from 800 kg/ha to 1600 kg/ha and each fertilizer that have been used contain 7% and 12% of phosphorus. However, the best optimum rate that can increase the yield of *B. oleracea* var *botrytis* is fertilizer that applied at rate on 100 kg/ha and 120 kg/ha. Similar trial of fertilizer rate also been applied on *Brassica oleracea* var *italica.* According to the yield of *B. oleracea* var *italica, the* most effective rate of phosphorus fertilizer was at rate of 125 kg/ha only. Thus, the result shows that *B. oleracea* var *botrytis* required more phosphorus fertilizer compared to B. *oleracea* var *italica*.

2.3 Commercial NPK Fertilizer

NPK fertilizer is complex fertilizers that contain three primary elements of nutrient that essential for plant such as N, P and K. Nowadays, Agricultural industry use NPK fertilizer to meet global demand and increase the production of crops. According to Blanco (2011), about half of global in food industry are using NPK fertilizer in their crops. NPK fertilizer is available in liquid, granular form and even in gaseous.

The three primary of macronutrient like nitrogen, potassium and phosphorus that important to plant can be found in commercial NPK fertilizer. There are many roles for each nutrient that contain in fertilizer such as N is the key element that can increase the growth of plants. N is vital in chlorophyll which can increase the rate of photosynthesis

and also act as basis in protein. N can be found in soil and atmosphere but depend on type of soil. Besides, N nutrient also can be found in urea, manure, compost and more (Carlson & Capitaine, 02018).

Other than that, there is also another nutrient that is important to plant which is phosphorus that contributing in structural strength of the plants, seed production and also can increase the crop quality. The sources of P is same like nitrogen which is can be found in both organic and inorganic sources such as in phosphate rock, bone meal, blood meal and more. Furthermore, there is potassium nutrient in NPK fertilizer that contributes to the growth and development of the crops. K nutrient play a major role in size, shape, colour and taste of the crops. Plant that receive insufficient amount of K can lead to stunted growth and low yield. K nutrient contain in manure, compost, wood ash and potash (Carlson & Capitaine, 2018).

2.4 Effect of organic and inorganic fertilizer on leafy vegetables

According to study done by Islam, Ayesha, Shahin, Tusher and Khanom (2012) on lettuce vegetables, the results shows that the highest production of lettuce was obtained by using organic fertilizer followed by inorganic fertilizer than control. The highest number of leaves, root length and yield were noticed by using cow dung compared to control. Besides, chicken manure contributes to leaves length, leaves breadth and base diameter of lettuce compared to other treatment such as cow dung and commercial fertilizer.

Besides, cow dung treatment also shows the highest yield production of lettuce. Hence, it is concluded that cow dung which is organic fertilizer was the best dose of fertilizer that can increase the growth and yield of lettuce.

Other than that, Lim and Vimala (2012) reported that the optimum application on yield of organic fertilizer were highest at 28.75 t/ha leaf mustard, 29.79 t/ha kangkung, 35.98 t/ha chinese spinach and 29.92 t/ha lettuce. The mean plant height of leaf mustard was increase from 19.6 cm at 24 days until 39.2 cm at 32 days. Besides, for the mean plant height of kangkung also increases from 33.1 cm at 22 days until 46.7 cm at 29 days while, for lettuce were 20.8 cm for both 48 and 54 days. For most of vegetables, the application of 20 t/ha of poultry manure gave comparable yields than 1 t/ha of inorganic fertilizer.

Furthermore, there was also study done by Xu et al., (2002) on leafy vegetables by using organic fertilizer. They stated that growth at early stage of leafy vegetables was lower compared to inorganic fertilizer due to lack of available nutrient in organic fertilizer. However, at later stages the leafy vegetables shows a better growth in organic fertilizer and resulted the highest yield compared to inorganic fertilizer and also improve the biological properties of the soil. Besides, the leaves concentration of sugar and vitamin C were significantly highest in organic fertilizer.

Moreover, based on studied done by Onyango, Harbinson, Shibairo, & Imungi (2011), found out that the highest yield of amaranth when applied with organic fertilizer like manure. They were use 20, 40 and 60 kg/ha of diammonium phosphate (DAP) and 40 N kg/ha of manure in order to observe the yield, vitamin C and nitrate level of the

plants. Organic fertilizer that been applied on the plant were increase in term of productivity of K and N level. However, DAP treatments also increase in yield of the plant but saturated at 40 N kg/ha.

Besides, there were studies done by Janet, Oluwafemi and Abiodun (2016) on *Solanum nigrum* L with application of organic and inorganic fertilizer. They were used 200 kg/ha of NPK and urea while, 6 t/ha of cow dung and poultry manure. The result shows that poultry manure produce the tallest plant (29.37 cm) after transplanting and high in number of green leaves (76.26 cm). Moreover, the leaf area, number of green leaves, shoot biomass and growth rate of *S. Nigrum* L. also highest in poultry manure but similar with inorganic fertilizer. It is suggested that poultry manure and cow dung were a good option to increase the growth of plants and also can reduce the cost of fertilizer especially for poor farmers because manure fertilizer were cheap and they also and they also can gain the fertilizer by their own livestock.

2.5 Studies Done by Using Vermiwash as Fertilizer

Indian agriculture use organic manure but the sources have been decrease with the introduction of intensive agriculture which demands for high nutrient. Unfortunately, they are increase in price index of chemical fertilizer due to energy crisis and limited of technology. Therefore, they look into another alternative which led to renewed interest in the use of organic manure. There is a need to look for other alternate sources of nutrient which is cheaper and eco-friendly to reduce the investment made on fertilizer and maintain soil fertility.

There was a study about vermiwash which applied to tomato plants in order to determine it growth and development of leaves and stem. Hemant, Puneeta, Jaya and Agrawal (2013) reported that the plants showed positive result when been treated with vermiwash. Hence, vermiwash proves to be an effective fertilizer which contributes to growth of plants when sprayed directly. They also observed that the plants treated with vermiwash were disease resistant and no pest were seen on the leaves and other parts of plants (Hemant, Puneeta, Jaya, & Agrawal, 2013).

Besides, according to the study of Girmary, Urgessa and Berecha (2016), the result shows significantly positive effect of coffee husk vermiwash on the growth and seedling of *Moringa stenopetala* and *Jatropha curcas*. The application of coffee hush vermiwash at 30 and 40% increase the quality of seedling. Then, the chlorophyll content for *M. Stenopetala* was higher compared to *J. curcas.* The seedling height increase when vermiwash concentration increase such as in concentration of 10%, 20%, 30%, and 40% were increase the plant height 4.3%. 4.8 %, 19.7% and 32.2% compared to control. Other than that, different concentration of coffee husk vermiwash also increases the leaf number of *J. curcas.* Coffee hush vermiwash at concentration of 10%, 20%, 30% and 40% were increase the leaf number 7.3 %, 15.2%, 24.7% and 24.9%.

Furthermore, Ayyobi et al., (2014) reported that growth of bean (*Phaseolus vulgaris L.)* was increase when applied with 7 t/ha vermiwash compared to 7 t/ha vermicompost. Plant that treated with vermiwash have a tallest plants (48.21 cm), longest pod (9.7 cm), increase number of pods and branches but the weight and longest internodes were increase for the plant that treated with vermicompost which is 5.1 g and 10.1 cm.

Then, it is interesting to know that in studied conducted by Maheswari, Srikumaran, Rekha, Elumalai, & Kaleena, (2016), also shows the same result on effect of vermiwash on plants. In this study, different concentration of vermiwash and panchagavya were used (5:2%, 10:3% and 15:4%) and been applied to the plant once in a week. The result shows that shoot length, internodes length, number of leaves and chlorophyll content of bean (*Dolichus lablab)* were highest when applied the vermiwash and panchagavya at concentration of 10:3%. Thus, it can be conclude that 10:3% of vermiwassh and panchagavya can be use as effective fertilizer on various crops in future.

In addition, according to study done by Chattopadhyay (2014), reported that vermiwash also can increase the growth and flowering of ornamental flower such as Zinnia sp. The result shows that 20% vermiwash and vermicompost showed the earlier bud initiation, increase number of leaves and plant height compared to 10% vermiwash and vermicompost. Besides, the number of flower also increases when applied with 20% V: V which is 35 flowers compared to 34 for 10% V: V. Treatment with 5% vermiwash and vermicompost increase flower production higher than control. Other than that, vermiwash also contribute in time of flowering which is 20% V: V increase the time of flowering compared to 10% V: V, 5%V: V and control. Combination vermiwash and vermicompost give positive effect on the growth and flowering of the ornamental plant compared to when used vermiwash or vermicompost only. Thus, both vermicompost and vermiwash can effectively use to sustain the plant production at green farming. Table 2.5.1 also showed studies done by others that using vermiwash on plants.

Table 2.5.1 (Cont): Other studies of vermiwash treatment

Table 2.5.1: The vermiwash treatment and its effect on other plant species

Vermiwash treatment	Concentration	Plant species	Percentage of enhancement	References
Vermiwash at different concentration	25 % and 50%	Brinjal (*Solanum melongena*)	Vermiwash at concentration of 25% increase 0.5 % height of brinjal while at concentration of 50 % increase 1.4%	Sundararasu and Jeyasankar, (2014)
	5% and 10 %	*Gladiolus grandiflorus* L.	Vermiwash at concentration 10% increase the weight of *G.grandiflorus L.* compared to 5% vermiwash	Tamrakar, (2016)
Vermiwash Gibberelic acid (GA) Naphtlene acetic acid (NAA)	15%	*Abelmoschus esculentus*	Weight *A. Esculentus* increase when applied with 15% vermiwash compared to GA and NAA	Elumalai, Kaleena, Fathima, & Hemavathi, (2013).

Vermiwash at one concentration	100%	Bean (*Phaseolus vulgaris*) Radish (*Raphanus sativus)*	Vermiwash at 100% concentration increase the root tip length of bean and radish	Abesekara, Sangakkara, & Mohotti, (2008).
Vermiwash with different dilution	1 :4 and 1 :3	Radish (*Raphanus sativus)*	Vermiwash with a dilution 1 :4 increase the root length of radish compared to 1 :3 vermiwash.	Jadhav, Kireeti, Patel, Dekhane, & Patil (2015).
Vermiwash at different concentration	5%, 10%, 15%,20% and 25%	Okra (*Abelmoschus esculentus* L.*)* Naga chilli (*Capsicum assamicum*)	Vermiwash at concentration of 20% show increase 11.93% in chlorophyll content of okra and Naga chilli as compared with control	Meghvansi, Khan, Gupta, Gogoi, & Singh (2012)

CHAPTER 3

METHODOLOGY

3.1 Materials

3.1.1 Earthworm and Plant Material

Earthworm from *Eisenia foetida* (red wiggler) species were bought from small company which is from private seller Chew Kok Hou at 16 Jalan SP 5/2, Taman Segar Perdana, 43200 Cheras Selangor (3.094053 ^{0}N; 101.760261 ^{0}E) Malaysia. The *B. rapa* seeds polybag and compost were bought from Lacjaya grocery at Ayer Lanas, Kelantan Malaysia. The equipments such as round container, draining tap, were bought at supermarket.

3.2 Methods

3.2.1 Preparation of Vermiwash

The set up of vermiwash unit was modified by the method from Ismail (1997). A round container of dimension 0f 89 x 89 x 90 cm (28 L) with a draining tap at the bottom of the container was placed a layer of broken brick or stone at the bottom of the container till approximately 5 cm higher than the draining point of the tap. A layer of soil and compost were placed on top of broken brick layer approximately 6 cm as the second layer and followed by a layer of goat dung approximately 5 cm (2 kg). Broken brick, soil, composing and cow dung were washed with running water until the overflowing water is clear.

Then, 150 earthworm adult belonging to the species *Eisenia foetida* were released to the vermiwash unit and followed by soil and composting layer approximately 5 cm. The unit were covered with jute cloth or any cover that function as a moisture trap. About 2 litres of water was poured in the vermiwash unit once in three days. Then, the vermiwash leachate were collected on 30 days by using plastic bottle which it will flow through the draining tap that was installed at the bottom of the container. Broken brick are use as the bottom layer to prevent water saturation.

3.2.2 Seedling Growth

The *B. rapa* seed were allowed to germinate in seedling tray that was filled with peat moss as a growing medium. For each hole, two seeds were planted about 2 cm depth, then after 2 weeks of germination, the seedlings were thinned out to one and transferred to into polybag by using 150 g of top soil as planting media. After that, 50 g/L of vermiwash stock were diluted with water until reached 100 g/L solution.

Then, the treatment was applied when the tested plant at the age of 2 and 4 weeks. Recommended rate for NPK fertilizer for leafy vegetables was 200 g/ha (Sanni, 2016) while 0.5 g/plant of commercial NPK fertilizer were applied in this study. Besides, recommended rate for organic foliar fertilizer was 145 g/ha (Fauzie, & Shampazuraini ,Amizi & Nazrin, 2015). Hence, based on recommended rate, 0.0003 g/plant of vermiwash was applied on the soil surface of plant according to its respected amount using pipette. The distilled water was applied as a control. The polybag were placed in the nursery.

Table 3.2.2: Treatments applied to the tested plant.

Treatment	Application rate (g/ha)
Control	0 g/plant
Commercial NPK fertilizer	0.4 g/plant of NPK was applied to the *B. rapa*
Vermiwash	0.0003 g/plant of vermiwash was applied to the *B. rapa*

3.2.3 Measurement of Growth Parameters

All the parameters were measured after 1 month of the treatment being applied to the plants. Plant height and the root length were measured by using the measuring tape. The weight of *B. rapa* were measured by using weighing scale and the chlorophyll content of leaves were measured by using spad meter. All the measurements were doing in three replicates. Then, the data will be analyzed.

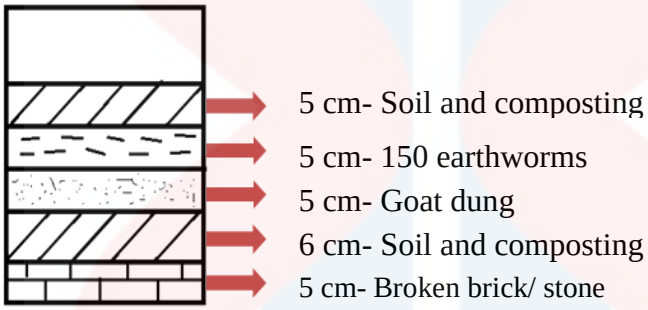
3.2.4 Statistical Analysis

All the treatments were carried out with 3 replicates which were arranged in a completely randomised design (CRD). All the data on the parameters studied were subjected to one-way analysis of variance (ANOVA) and differences between means for significance under significance level of <0.05 were calculated. Computer software SPSS was used for statistical analysis (Muhammad & Majeed, 2014). Tukey HSD was used to compare mean among the treatments. Differences are regarded as significant when the p-values are less than 0.005 ($P<0.005$).

3.3 Research flow chart

Earthworms were bought from Mr. Chew at Cheras Selangor while *B. Rapa* seeds and other plant material were bought from Lacjaya grocery

Vermiwash preparation:



Two seeds of *B. rapa* were planted for each hole in seedling tray. Seedling were thinned out to a one and transferred into polybag (after 2 weeks of germination)

Then on week 2 and week 4, 0.0003 g/plant of vermiwash were applied on the surface 0f soil by using micropipette. While, 0.4 g/plant of commercial NPK fertilizer were applied on the plant and 0 g/plant for untreated B. *rapa*.

All the parameters were measured after 1 month of the treatment being applied to the plants which is plant height, root length, weight and chlorophyll content

Figure 3.3: Research flow chart

CHAPTER 4

RESULT AND DISCUSSION

4.1 Plant Height of *B. Rapa.*

Figure 4.1 shows that the height of *B. rapa* is increasing 52% when treated with vermiwash (527 cm) while 51% for commercial NPK fertilizer (253 cm). Besides, there are significant different between control and vermiwash treatment on the plant height on of *B. rapa* and follow by significant different between commercial NPK fertilizer with vermiwash (Appendix A).

In the present investigation by Sundararasu and Jeyasankar (2014), the plant height of brinjal (*Solanum melongena*) in response to different concentration of vermiwash shows that 25% vermiwash with 75% of water resulted the plant height as much 50.1 cm and 50% vermiwash diluted with 50% water increase the plant height 50.8 cm when compared control 49.84 cm. They found out that when increasing in concentration of vermiwash will increase the brinjal (*Solanum melongena*) due to decrease in soil copper which might be leached away when they applied higher concentration of vermiwash.

Similarly, Sundararasu (2017) also found out that vermiwash with different concentration affected growth of chilli (*Capsicum annuum*). His study shows that concentration of 50% vermiwash that diluted with 50% of water was the most effective concentration which increase the plant height up to 97 cm compared to concentration of 60% vermiwash with 40% of water which was 88 cm. Then, followed by other concentration like 40 % vermiwash with 60% of water which show the result 85 cm and 82 cm for control based on the plant height. Besides, Manyuchi, Kadzungura, Phiri and Muredzi (2013) also stated that increase of vermiwash quantity and increase application time can enhance the height of Zea Mays.

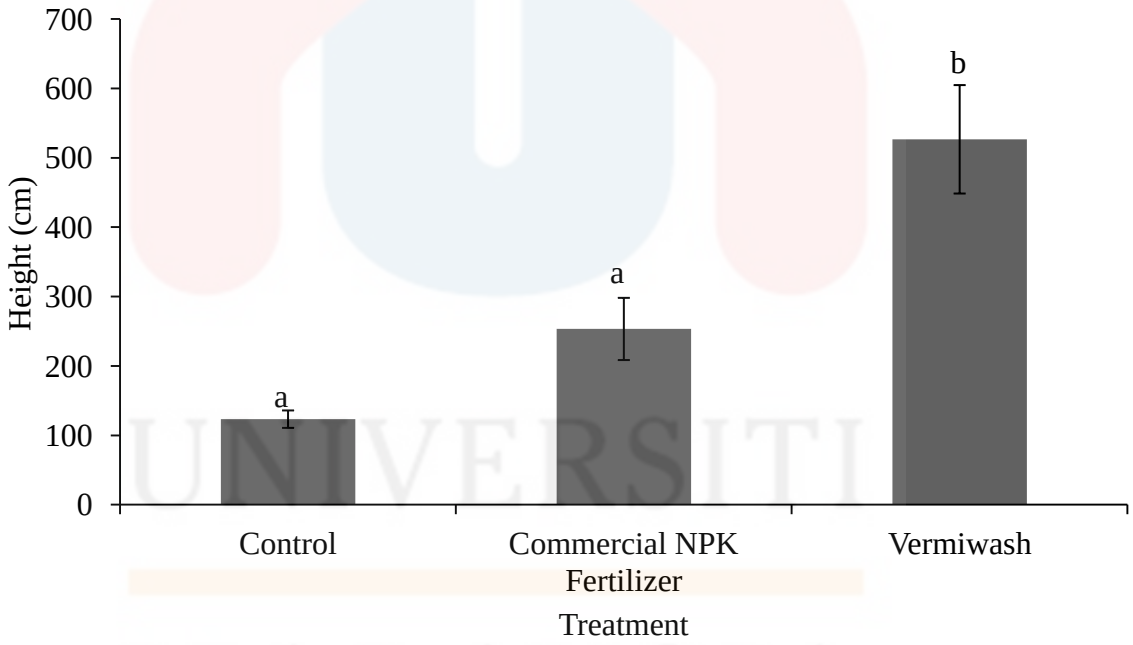


Figure 4.1: Effect of vermiwash and commercial NPK fertilizer on the plant height of *B. rapa*. Vertical bars represents standard deviation (SD) of the mean.

4.2 Plant Weight of *B. Rapa.*

It is interesting to note that vermiwash shows similar effect in term of plant weight when compared with commercial NPK fertilizer and control (Figure 4.2). Vermiwash increase 64% weight of *B. rapa* (57 g) compared to 59% for commercial NPK fertilizer (140 g). There was significance different between vermiwash and NPK, so vermiwash performed significance better than NPK (Appendix B). In the other hand, there was significance different between control and vermiwash treatment. This shows that the vermiwash treatment help to enhance the weight of *B. rapa*.

Study done by Tamrakar (2016) *Gladiolus grandiflorus* L. presented the result where vermiwash with 10% concentration have the highest weight of *Gladiolus grandiflorus* L. cormels was 18.32 g compared to 17.82 g of cormels for 5% vermiwash. According to Elumalai, Kaleena, Fathima, and Hemavathi, (2013) the highest weight of *Abelmoschus esculentus* when treated with vermiwash 15% was 44.47 g compared to other treatments such as 26.99 g for gibberelic acid and 24.25 g for naphthalene acetic acid.

The results in this study also in line with the study conducted by Bhardwaj and Sharm (2016), where there was increase in term of plant weight of *Vigna radiatawas* when the plant were treated with 500 ml of vermiwash (1.06 g) compared to 0.88 g for 15 t/ha of vermicompost. Besides, they also applied commercial NPK fertilizer and 15t/ha of cow dung on the plant and weight of seed *Vigna radiatawas* for cow dung was 0.68 g. Vermiwash treatment is the most effective fertilizer in enhance weight of plant compared to vermicompost, commercial NPK fertilizer and cow dung treatment.

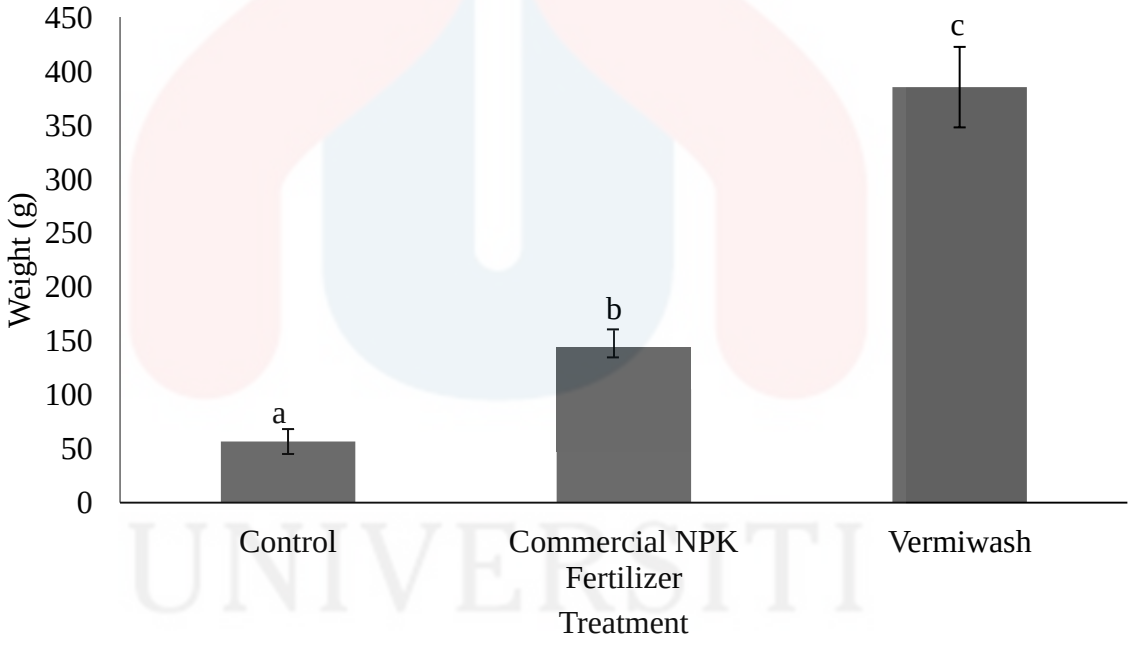


Figure 4.2: Effect of vermiwash and commercial NPK fertilizer on the plant weight of *B. rapa*. Vertical bars represents standard deviation (SD) of the mean.

4.3 Plant Root Length of *B. Rapa.*

The application of vermiwash treatment displayed 277 cm root length of *B. rapa* that increase 17% compared to 231 cm for commercial NPK fertilizer (Figure 4.3). Other than that, there were increases 54% in root long for commercial NPK fertilizer when compared to 107 cm of control. Furthermore, there were significant different between control and vermiwash treatment (Appendix C). This result shows that vermiwash can promote the root length of *B. rapa* which is important for water and nutrient uptake.

According to a study conducted by Abesekara, Sangakkara and Mohotti (2008), vermiwash at 100% concentration on the root tip length of bean (*Phaseolus vulgaris*) and radish (*Raphanus sativus*) seedling shows an increased of the root tip length of bean and radish. The root tip of bean was 0.003 cm and 0.0033 cm while radish was 0.0021 cm and 0.0015 cm. The increasing of root tip length is due to plant growth regulatory activity that contain in the vermiwash.

Besides, study done by Elumalai, Kaleena, Fathima, and Hemavathi (2013), found that the maximum root length of *Abelmoschus esculentus* when treated with vermiwash at 15% give a result of 18.100 cm compared to gibberelic acid treatment which was 13.367 cm and 12.467 cm for naphthalene acetic acid. Then, the result also shows that the percentage of increment root length for vermiwash was highest which 63.55% compared to 20.78% in gibberelic acid treatment and 12.65% in naphthalene acetic acid.

Then, Jadhav, Kireeti, Patil, Dekhane, and Patel (2015), also did a study to investigate the effectiveness of vermiwash in enhancing the growth of root length of radish (*Raphanus sativus* L.). In their study, they reported that the different dilution of vermiwash give different result of root length such as vermiwash and water at 1:4 showed the maximum root length which was 1.041 cm while other root length for 1: 3 vermiwash: water is 0.99 cm.

Jaybhaye and Bhalerao (2015), observed a similar increase of the root length of *Vigna radiata* and *Vigna mungo* when applied vermiwash at different concentration of 10%, 20% and 30%. The result shows that there were increase 26% of *V. radiate* of root length (5.37 cm) on 30% concentration while the root length (4.00 cm) increase 19% when 20% concentration of vermiwash were applied. Besides, there were also 15% increases of root length (7.50 cm) of *V.mungo* when applied the vermiwash at 30% concentration compared to increase 22% of root length (6.37 cm). Thus, the result shows that the highest concentration of vermiwash can enhance the growth of root length.

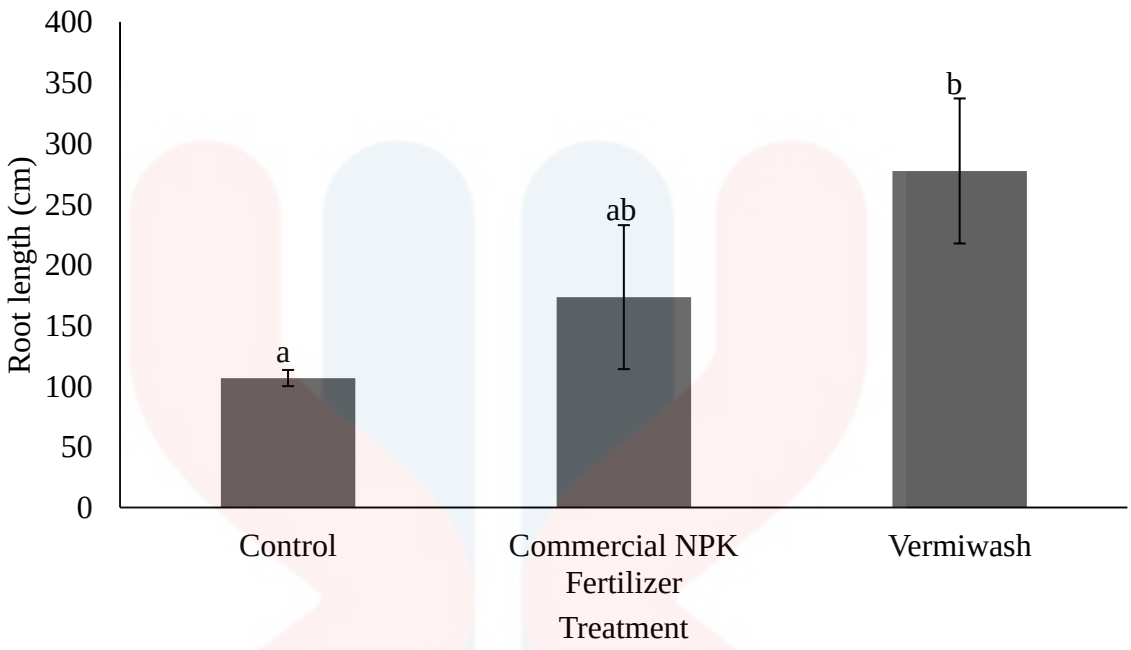


Figure 4.3: Effect of vermiwash and NPK treatments on the root length of *B. rapa.*

Vertical bars respresent standard deviation (SD) of the mean.

4.4 Plant Chlorophyll Content of *B. Rapa.*

The effect of vermiwash treatment on the chlorophyll content of *B. rapa* in Figure 4.4 shows increasing of 21% when treated with vermiwash (129 nm) compared to 3% of commercial NPK fertilizer (102 nm). However, there is no significant different between vermiwash treatment and NPK treatment (Appendix D). This result shows the chlorophyll content of *B. rapa* not really influenced by the vermiwash treatment and commercial NPK fertilizer. In previous study by Meghvansi, Khan, Gupta, Gogoi, and Singh (2012), they found out that maximum of chlorophyll content for Naga chilli was 45% when be treated with 25% of vermiwash compared to control which 37.5%.

Likewise, Quaik, Embrandiri, Rupani, Singh, and Ibrahim (2012) found that the highest of chlorophyll content of Indian Borage (*Plectranthus ambionicus*) when 10% vermiwash treatment was applied to the plants. The result indicates that total chlorophyll content for Indian Borage was 0.37 mg/g which is the highest compared to 19% vermicomposting and control. Besides, there are other study that have been done which can use to support that vermiwash contains lot of nutrient which is excellent for plant growth.

Based on a study done by Suthar, (2010), result shows that the highest chlorophyll content in fresh leaves of *Trigonella foenum-graecum* that treated with 100% vermiwash treatment was 1.51 mg/g compared to 1.3 mg/g for 50% vermiwash. Besides, for *Cyamopsis tertagonoloba* also showed 1.5 mg/g for chlorophyll content when treated with 100% vermiwash and 1.2 mg/g for 50% vermiwash treatment.

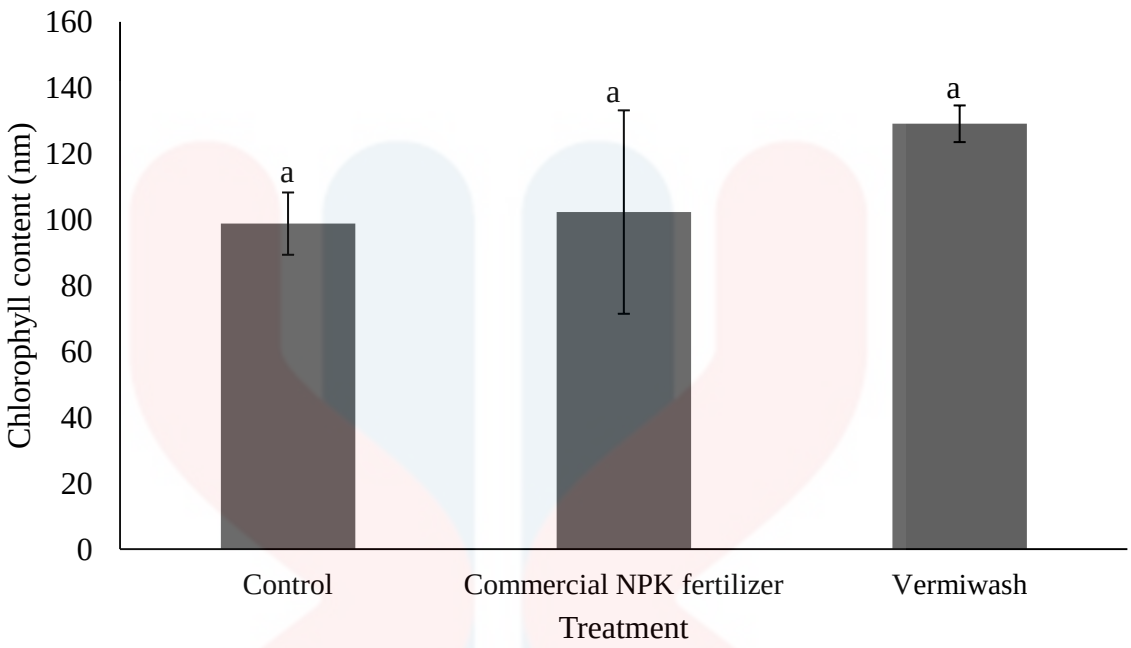


Figure 4.4: Effect of vermiwash and NPK treatments on the chlorophyll content of *B. rapa.* Vertical bars represent standard deviation (SD) of the mean.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In the nut shell, vermiwash leachate always used for enhancing the growth of plant. Vermiwash leachate that produced from microorganism activities during vermicomposting process has a high plant nutrient content that play an important role in improving growth and increase the yield of many types of crops including vegetables, ornamental, herbs, fruit plants and more. Besides, the growth performance parameters show the stimulating effect from the application of vermiwash treatment to *B. rapa* plant. There are significant different in the height of *B. rapa* between the treated plants of vermiwash treatment with untreated control. Then, there were significant different between NPK fertilizer with vermiwash treatment. Vermiwash increase 52% of plant height (527 cm) while commercial NPK fertilizer increases 51 % height of *B. rapa* (253 cm).

Furthermore, weight of *B. rapa* also shows the significant different between all the treatment. Vermiwash increase 64 % weight of the plant (57 cm) while commercial NPK fertilizer (140 cm) enhances the weight of plant about 59%. Likewise, there were also significant different in term of root length between control and vermiwash treatment. Application of commercial NPK fertilizer increase 54% of root length (231 cm) compared to 17% of vermiwash (277 cm).

However, there is no significant different for the chlorophyll content of *B. rapa.* Otherwise, vermiwash treatment (129 nm) increases 21% of chlorophyll content while, commercial NPK fertilizer (102 nm) increases 3% of chlorophyll content of *B. rapa.* It can be conclude that the vermiwash leachate has a potential to be developed as organic fertilizer that can enhance the growth of plants.

5.2 Recommendation

Vermiwash leachate should be commercialized because these organic fertilizers have lot of potential as bio-fertilizer. Therefore, for further study should be done on the analysis of the soil physical-chemicals properties in order to know the effect of vermiwash on soil pH, electricity conductivity and content of N, P and K in the soil. The value of soil pH as a result of decomposition of organic matter by microbial activity that produce carbon dioxide and other organic acid that present in the soil. Thus, it is important to know the soil physical-chemical properties in order to choose the best fertilizer that can increase soil fertility and plants growth. Likewise, soil properties and micro-organisms present in the vermiwash play a critical role on the modification of the soil physicochemical properties.

In addition to that, further this study until it reaches the yield production stage. So that, the quality of *B. rapa* can be determine by using vermiwash leachate. Furthermore, application of vermiwash that consider as organic fertilizer is much recommended to use on the crops because it is ecologically safe and can boots to rural economy.

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APPENDIX A

1. **Effect of vermiwash and commercial NPK fertilizer on the plant height of *Brassica rapa* var *chinensis.***

Tukey HSD[a]

Treatment	N	Subset for alpha = 0.05	
		1	2
Control	3	123.3333	
Commercial NPK fertilizer	3	253.3333	
Vermiwash	3		526.6667
Sig.		.052	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

APPENDIX B

1. Effect of vermiwash and commercial NPK fertilizer on the plant weight of *Brassica rapa* var *chinensis.*

Tukey HSD[a,b]

Treatment	N	Subset for alpha = 0.05		
		1	2	3
Control	3	56.6667		
Commercial NPK fertilizer	3		140.0000	
Vermiwash	6			385.0000
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.600.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

APPENDIX C

1. Effect of vermiwash and commercial NPK fertilizer on the plant root length of *Brassica rapa* var *chinensis.*

Tukey HSD[a,b]

Treatment	N	Subset for alpha = 0.05	
		1	2
Control	3	106.6667	
Commercial NPK fertilizer	3		231.0000
Vermiwash	6		277.3333
Sig.		1.000	.490

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.600.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

APPENDIX D

1. Effect of vermiwash and commercial NPK fertilizer on the plant chlorophyll content of *Brassica rapa* var *chinensis.*

Tukey HSD[a,b]

Treatment	N	Subset for alpha = 0.05
		1
Control	3	98.6667
Commercial NPK fertilizer	3	102.3333
Vermiwash	4	129.0000
Sig.		.138

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.273.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

APPENDIX E

1. One Way ANOVA for height, weight, root length and chlorophyll content of *Brassica rapa* var *chinensis*

		N	Mean	Std. Deviation
Height	Control	3	123.3333	12.58306
	Commercial NPK fertilizer	3	253.3333	44.81443
	Vermiwash	3	526.6667	78.15583
	Total	9	301.1111	183.99691
Weight	Control	3	56.6667	11.54701
	Commercial NPK fertilizer	3	140.0000	10.00000
	Vermiwash	6	385.0000	37.28270
	Total	12	241.6667	155.02688
Root length	Control	3	106.6667	6.50641
	Commercial NPK fertilizer	3	231.0000	58.92368
	Vermiwash	6	277.3333	59.52030
	Total	12	223.0833	86.99369
Chlorophyll content	Control	3	98.6667	9.07377
	Commercial NPK fertilizer	3	102.3333	30.92464
	Vermiwash	4	129.0000	5.59762
	Total	10	111.9000	21.44994