Effects of Bokashi and Application of Monosodium Glutamate (MSG) as Foliar Fertilizer on Selected Soil Characteristics and Growth Performance of Pak Choy (*Brassica rapa subs chinensis)*

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DECLARATION

I declare that this thesis entitled "Effects of Bokashi and Application of Monosodium Glutamate (MSG) as Foliar Fertilizer on Selected Soil Characteristics and Growth Performance of Pak Choy *(Brassica Chinensis L.)*" is the result of my own research except that cited in the references.

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Sincerely,

Amirah binti Ayob

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ABSTRACT

Pak Choy has many advantages to human health such as anti cancer and can rise the vitamin consumption for human. The purpose of this study was to determine the optimum rate of organic fertilizer in the production of *Brassica chinensis* (Pak Choy). This study has two experiments which in greenhouse and in open field. As for the greenhouse, the experimental design used is completely randomized design (CRD) consisting of 5 Bokashi levels and each treatment is replicated three times. Monosodium Glutamate (MSG) also has 5 levels and it is applied by foliar application. The interaction between Bokashi and MSG was investigated by 2×3 factorial experiment with 3 replications that was arranged in Completely Randomized Block Design (CRBD). The parameters evaluated were growth performance (height of the plants, diameter of branches, number of leaves and chlorophyll content), soil characteristics (soil organic matter, soil pH) and biomass production. The results show Bokashi with treatment 3 has better growth performance with the 16.9cm of height, 1.58cm diameter of branch, 10 leaf number, 38.7 chlorophyll content, 430g of fresh weight and 0.115g of dry weight. MSG with treatment 3 resulted the highest growth performance with 12.3 cm of height, 0.78 cm diameter of branch, 8 leaf number, 37.7 chlorophyll content and 128g of fresh weights. The soil organic matter and soil carbon in all treatments was decreased and shows no effect in applying fertiliser. Soil pH was consistent and shows no effect in applying fertiliser. As for the experiment in open field, there were interactions between the Bokashi and MSG towards height of the plant and number of leaf. However, there is no interaction between Bokashi and MSG towards diameter of branch.

Keywords: *Bokashi, Monosodium Glutamate(MSG), Brassica chinensis, foliar application, and NPK*

Kesan Bokashi dan Penggunaan Monosodium Glutamate (MSG) sebagai Baja Foliar pada Ciri-ciri Tanah yang Terpilih dan Prestasi Pertumbuhan Pak Choy *(Brassica rapa subs. chinensis)*

ABSTRAK

Pak Choy mempunyai banyak kelebihan kepada kesihatan manusia seperti anti kanser dan dapat meningkatkan penggunaan vitamin untuk manusia. Tujuan kajian ini adalah untuk menentukan kadar baja organik optimum dalam pengeluaran *Brassica chinensis* (Pak Choy). Kajian ini mempunyai dua eksperimen yang terdapat dalam rumah hijau dan di batas. Bagi rumah hijau, reka bentuk eksperimen yang digunakan adalah reka bentuk sepenuhnya rawak (RUL) yang terdiri daripada 5 tahap Bokashi dan setiap rawatan diulang sebanyak tiga kali. Monosodium glutamat (MSG) juga mempunyai 5 tahap dan ia digunakan oleh aplikasi daun. Interaksi antara Bokashi dan MSG dianalisis oleh 2 × 3 eksperimen faktorial dengan 3 ulangan yang disusun dalam Rancangan Blok Rawak sepenuhnya. Parameter yang dinilai adalah prestasi pertumbuhan (ketinggian tanaman, diameter cawangan, jumlah daun dan kandungan klorofil), ciri tanah (bahan organik tanah, pH tanah) dan pengeluaran biojisim. Keputusan menunjukkan Bokashi dengan rawatan 3 mempunyai prestasi pertumbuhan yang lebih baik dengan ketinggian 16.9cm, diameter 1.58cm dahan, 10 bilangan daun, 38.7 kandungan klorofil, 430g berat segar dan 0.115g berat kering. MSG dengan rawatan 3 menghasilkan prestasi pertumbuhan tertinggi dengan ketinggian 12.3 cm, diameter dahan 0.78 cm, 8 bilangan daun, 37.7 kandungan klorofil dan 128g berat segar. Bahan organik tanah dan karbon tanah dalam semua rawatan telah menurun dan tidak memberi kesan dalam penggunaan baja. PH tanah adalah konsisten dan tidak memberi kesan dengan penggunaan baja. Bagi percubaan dalam batas, terdapat interaksi antara Bokashi dan MSG terhadap ketinggian tanaman dan bilangan daun. Walaubagaimanapun, tiada interaksi antara Bokashi dan MSG terhadap diameter dahan.

Kata kunci: *Bokashi, Monosodium Glutamate (MSG), Brassica chinensis, aplikasi foliar dan NPK*

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
NPK	Nitrogen Phosphorus Potassium
MSG	Monosodium Glutamate

LIST OF SYMBOLS

cm	Centimetre
g	Gram
ha	Hectare
m	Metre
℃	Celsius
%	Percentage

CHAPTER 1

INTRODUCTION

1.0 Background of Study

Among 51 genera in the tribe of Brassiceae, there is genus Brassica that belongs to Crucifer family and it is the most important genus in the tribe and also contains 37 different species (Canada, 2004).Seven groups of vegetable B. rapa types are known, and these are: var. campestris, var. pekinensis, var. chinensis, var. parachinensis, var. narinosa, var. japonica and var.rapa. Until recently, these groups were considered as separate species because of the wide range of variability they represent and the fact that they evolved in isolation from each Pak Choy (Canada, 2004). Mustard is higher in phytonutrients, minerals and antioxidants such as sinalbin, sinigrin and vitamins. Pak Choy was categorized in mustard family. Pak Choy also had known as *Brassica Chinensis L.* (1759), *Brassica Campestris L. subsp. Chinensis (L.), Brassicarapa L. subsp. Chinensis (L.)*(Makino,1912).

Pak Choy came from China and belongs to Brassicaeae family, and it was categorized as leafy vegetable plant. Pak Choy has high productivity and can be harvested in the short time period (20-25 days after transplant) and also not sensitive temperature changes. Every 100g of fresh weight of Pak Choy contains 92.2% water, 3.9% carbohydrates, 1.8% proteins, 07% fibre and 0.9% ash. Pak Choy can be stored up to 10 days with the relative humidity of 95% and temperature of 0-5°C. Vitamins and minerals such as ß-carotene, vitamin C, Calcium, Phosphorus and Iron also contains in Pak Choy (Silitonga, Sipayung, & Sitorus, 2018).

It is very important to conserve mustard and find innovation that can increase the mustard production because it has many advantages. Seventy years ago modern cancer chemotherapy was initiated because of the discovery of the antineoplastic activity of nitrogen mustard. Mustard also has nitrogen that can be anticancer agents (Singh, Kumar, Prasad, & Bhardwaj, 2018). The first anticancer agents are the nitrogen mustard based on DNA alkylating agents and it also an important drug that can prevent anytypes of cancer (Singh *et al.*, 2018).

Vegetables is one of the food component that can give many nutrition and also beneficial for human consumption. Human was aware with this issues and plant white mustard for the better consumption (Kusuma, 2012). Vegetables also can help to prevent any disease with their own speciality. White mustard, *Brassica chinensis* has many benefits such as can prevent osteoporosis. It has high content of vitamin K, A, C, E and Magnesium and Potassium mineral and gives human better nutrition with consuming 419,3 mKg per mustard (Nisa, 2013).

The mustard plant also has volatile oil that has strong antimicrobial such as bacteria and fungi properties. Plants that produce essential oil naturally is in cruciferous plants such as mustard, broccoli, horseradish, cabbage, cauliflower, kale and turnips in the seeds, stems, leaves, and roots of cruciferous plants (Nielsen & Rios, 2000).

Foliar fertilizer is an effective ways to enhance the growth of plant because it helps nutrients stick to the leaf and absorb through the stomata and epidermis. It also penetrates to the leaves cuticle. Thus, foliar feeding also can avoid leaching out from the soil and give quick reaction in plant because of the fast absorption. In this study, Bokashi and MSG were applied to compare the effects on soil characteristics and growth performance of mustard.

Bokashi is a Japenese term that means fermented organic matter. It also gives positive impact to the plant growth such as increasing the growth rate. Bokashi is a type of compost and actually having anaerobic fermentation process. There are many advantages in using Bokashi as fertilizer such as it is easy to handle. The bad odors also can be prevented with the using of Bokashi as fertilizer Kujira, (2000) observed that root system and yield of paddy rice were improved after Bokashi application. The positive impact of using EM Bokashi as fertilizer is it can enhance soil organic matter content.

1.1 Problem Statement

The dilution of Monosodium Glutamate (MSG) was use in applying foliar fertiliser. However, there is little information about the use of Monosodium Glutamate (MSG) as foliar fertilizer on soil characteristics and growth performance of Pak Choy (*Brassica rapa subs chinensis.*). Monosodium Glutamate (MSG) is a chemical substance that can use in human food and give some effect on human if uncontrolled uptake. The rates of MSG also difficult to estimate because there was not much scientific study that prove MSG give positive effect on plant growth. The ingredient in the MSG that reacts with the plant is also not known. The time needed for MSG to absorb at the epidermis of leaf also is not exactly known.

The absorption at the surface of epidermis of the plants may be different from the nutrient absorption by using roots. For example, foliar application can be efficient as it can repair the failure taken of Zinc because of the chemical constraint such as in alkaline soils because of precipitation (Cakmak, 2008). So, this research was being done to explain the efficiency of foliar fertiliser towards the plant.

1.2 Objective

1. To determine the optimum rate of Bokashi and MSG towards the growth performance and soil characteristics.

2. To observe the effect of Bokashi and MSG towards the growth performance and soil characteristics.
3. To evaluate effect or interaction between Monosodium Glutamate and Bokashi towards growth performance and soil characteristics.

1.3 Hypothesis

Ho: There are no significant different towards the effects of Bokashi and application of monosodium glutamate (MSG) as foliar fertilizer on soil characteristics and growth performance of mustard.

H1: There are significant difference towards the effects of Bokashi and application of monosodium glutamate (MSG) as foliar fertilizer on soil characteristics and growth performance of mustard.

1.4 Significance of Study

This study could contribute to the improvement of the crop production and give advantages to the small and large-scale company. The production could be increase and also can enhance the quality of the crop planted such as growth performance. This research also rebound to the benefit of economy because plant is an important element. The greater demand of the crop plant also was fulfilled because of the increase of the productivity of the crop. The soil characteristics also could be improved with the observation of the research such as the texture, color and pH value.

CHAPTER 2

LITERATURE REVIEW

2.1 Morphology of Brassica rapa subs. Chinensis

Chinese cabbage non-heading type includes B. rapa subsp. Chinensis (Opeňa, 1988). Pak choi, Bok Choi and Tat soi was includes in *ssp. Chinensis*. Non-heading Chinese cabbage has a short growing season. Pak Choy is a flowering vegetable and also an annual plant (Hill, 1990). The characteristic of Pak choi (ssp. chinensis) was does not form a head and has darker green support by light green that form a rosette (Hill *et. al*, 1990), smooth leaves with a pronounced white midrib (Zhao & Wang, 2005). The height of the plant was ranges between 15cm to 30cm at the end of the vegetative stage depend on the cultivar. The time taken from sowing to the end of the vegetative stage was about six weeks for early matured to 11 weeks for late mature cultivar (Hong Fu, 1988). Depending on the cultivar, the plants reach a height of 15 cm to 30 cm at the end of the vegetative stage.

2.2 Bokashi fertiliser

Bokashi come from Japanese term means “organic matter that was fermented”, Bokashi used fermentation and use decomposer bacteria or EM (*Effective Microorganism*). Bokashi was used by Japan farmer to fit the condition of the soil using traditional method to increase the microbe effects in the soil and increase the nutrients element of the soil (Nasir, 2007). Bokashi also be an acronym from organic rich ingredient source of life describe the things that was used to make Bokashi were organic matter that was fermented by EM (Salam,2008). The process of Bokashi can be divided into two categories such as aerobic Bokashi and anaerobic Bokashi. The preparation of Bokashi including any kind of animal dung and EM that was used by fermented compost (Lanka, 2013).

2.2 Characteristics of Bokashi

The variations of feed stock effects the difference in chemical characteristics. There is low C:N ratios of 10-11:1 that was reported on some studies with ammonium as the dominant inorganic nitrogen form is a common characteristic (Daiss, 2008). Bokashi amendments also have poor characterization of other macronutrient and micronutrient level although there are efforts to explain its effect on soil fertility once it was applied (Hu and Qi, 2013).Bokashi amendments that were applied to soil in coffee system also increase alkaline phosphate, urea’s activity and acid (Gómez-Velasco, 2014). A study evaluated the effects of EM Bokashi applications on soil bacterial 6 community structure and found that the amendment altered community structure in the short term, however in less than one year the indigenous soil community structure returned (Mayer, 2010).

2.3 EM Bokashi

There are three naturally occur species such as phototrophic bacteria, lactic acid bacteria and yeasts that was used in fermented mixed culture of EM in acidic medium which is pH below 3.5.The source material of EM includes 5 main groups of microorganisms such as lactic acid bacteria (Lactobacillus Plantarum, L. Casei, and Streptococcus Lactis), photosynthetic bacteria (Rhodopseudomonas Palustrus and Rhodobacter Spaeroides), yeasts (Saccharomyces cerevisiae and Candida Utilis), actinomycetes (Streptomyces Albus, S. griseus) and fermenting fungi (Aspergillus Oryzae, Penicillium sp. and Mucor Hiemalis) (Khaliq, 2006;Mayer, 2010) The filamentous fungi and actinomycetes enriched the mixture naturally (Higa Professor of Horticulture & Parr, 1994).

The inoculation of EM culture to the plant ecosystem and soil can improve yield, growth and quality of the crops and enhances chemical and physical properties of the soil as shown in many research and field studies (Xu HL, 2000). The beneficial effects of crop management practices and soil in organic farming also can be improved by the use of EM (KM, 2003). The organic matter fermented with is known as Bokashi. This mixture is called EM-Bokashi and the ability of microorganism to break down organic matter also can be improved and provide the plant nutrients make better yield and quality (Yan PS, 2002). EM Bokashi also results increasing in crop production of vegetable, rice and sweet corn in some research (Wahori, 1996; Iwashi, 1994; Fujita, 1997).

2.4 Advantages of Bokashi

The application of Bokashi increased the production of tomatoes. The same result also was shown towards tomatoes (Togund & Akanbi, 2003; Neliyati, 2006), beans (Koesrini & William, 2009), onion (Mayun, 2007), potatoes (Danilchenko et al., 2005), chilli (Sutari et al., 2003) and leafy vegetables (Iskandar, 2003). This is because the application of Bokashi can improve biology, physical and chemical characteristics of soil. Organic matter can improve the elongation of roots deeper in the soil and the plant can absorb nutrients and large amount of water (Gonzalez danCooperband, 2002). Effective microorganism was being used in making Bokashi. It can improved soil condition, suppress disease and improve efficiency of organic matter that was used by crops.

EM application is widely used in many countries for crop production. The yield can be increased and the quality was being improved by the use of EM. Plant nutrients can be increased or direct benefit on plant growth, health and protection (Bevacqua and Mellano 1994; Stolze et al. 2000;Xiaohou, Min, Ping, & Weiling, 2008). Bokashi application shows improvements in soil fertility and crop growth and some studies reported negligible effects (Gómez-Velasco et. al. 2014, Lima et. al. 2015, Xu et. al.

2001, Mayer et. al. 2010). For example, a study in China showed grain yields, nutrient content in grain and straw and straw biomass in wheat significantly increased with the application of EM Bokashi (Hu and Qi, 2013). There also inconsistent effects of Bokashi on the yields of potatoes, winter 24 barley and alfalfa in a study in Switzerland (Mayer et. al. 2010).

2.5 Effects of Bokashi towards crop

The solid agricultural byproducts ware derived to an anaerobic fermentation product such as EM-Bokashi (Higa and Parr, 1994). Bokashi was also provides a suitable microenvironment for EM of the soil also the growth medium of the microorganism. The effect of Bokashi is on soil health, yield of crop and plant protection have been tested by EM products. There were positive effects of EM to enhance of the growth, yield and quality of crops included bean (Javaid and Bajwa, 2011; Roberti et al., 2015; Talaat, 2015), corn (Bruggenwert, 1999; Xu, 2001), grass (Bruggenwert, 1999), pea (Javaid, 2006), peanut (Yan and Xu, 2002), rice (Iwaishi, 2000), tomato (Ndona et al., 2011; Xu et al., 2000), and wheat (Hu and Qi, 2013).

There are several research shows that there are no negative effect of EM application such as no effects on aboveground plant biomass of sweet corn (Priyadi et al., 2005) or grass (van Vliet et al., 2006), and on the yield of cotton (Khaliq et al., 2006) and sugar beet (Wilting, 1999). EM has no effect towards nitrogen contents of grass (van Vliet et al., 2006), and the microbial of biomass C and N, N mineralization, and bacterial diversity in soil (SchenckZu Schweinsberg-Mickan & Müller, 2009; van Vliet et al., 2006).

2.6 Advantages of Effective Microorganism

New technology can be appeared by the use of beneficial and effective microorganisms (EM) as microbial inoculants in agriculture. The nutrition of wheat straw biomass, grain yields and straw can be enhanced with the use of EM application. High efficiency of the release of nutrition was shows with the highest NPK content in plant tissues that combine with EM compost treatment (Hu and Qi, 2013). The soil healthy and quality can be improved, the yield can be rise and the quality of the crop increased with the use of EM. The yield of the plantation and all application is increasing with the use of effective microorganisms (Szymanski&Patterson, 2003; Khaliq et al., 2006; Shah et al., 2001; Javaid, 2006; Ncube et al., 2011; Melloni et al., 1995; Muthaura et al., 2010; Vetayasuporn, 2004). The survival of plants under saline conditions can be improved and the oxidative damage towards plants cell could be protected by EM application.

The sustainable environment can be improved by EM and also offers a real opportunity for eco innovation (Talaat, 2014).*Lactobacillus sp*, yeast and mushrooms with *Cellulyotic bacillus sp* were bacteria that act as decomposer of organic matter, agriculture and farming. It was able to decrease the ratio C/N in the rubbish, animal dung and rice straw that have high content (>50) and turn to be normal as C/N of the soil. The ratio within carbohydrate and nitrogen is low as C/N of the soil (<20) makes the of rice straw as the Bokashi fertiliser can give nutrition to the plant.

2.7 Chemical Characteristics of Monosodium Glutamate (MSG)

Liquid fertiliser of Monosodium Glutamate was being used as organic fertiliser because it contains many nutrients and has high content of organic matter. MSG came from acid glutamate and including in acid amino type. The process of making MSG contains many nutrients that make the liquid MSG that was produced have high content of N.

Monosodium glutamate commonly known as white crystalline powder and has molecular weight of 187.13 and significantly soluble in water. MSG was found to be stable and it was also not hygroscopic and it does not change in quality or appearance during storage in room temperature. MSG also does not decompose except in acid condition such as 2.2-2.4 and at higher temperature also even when cooking or food processing. MSG partially dehydrated and being converted into 5-pyrrolidine-2-carboylate at pH level of 2.2-2.4. Glutamates will racemes to D,L glutamate at very high temperature and under alkaline conditions (Wijayasekara & Wansapala, 2017).

2.8 Foliar application of fertiliser

Photosynthesis plays an important organ that located at green leaves. The absorption of inorganic and organic material that can make photosynthesis process through the surface of leaves shows least evidence that available (Franke, 1967). There will be different in nutrient absorption of leaves compared by roots structure because the leaf of cell wall was covered with cuticle. Both organic and inorganic ions and dissociated molecules are permeable through the cuticle membranes. The green leave from photosynthesis proves that the energy is required for active absorption were derived from respiratory metabolism. The rates of ion absorption by leaves were improved by light quality and intensity.

Franke *et al*. (1967) suggested that ion uptake by leaves may be completed in three stages. In the first stage, substances applied to the leaf surface penetrate the cuticle and the cellulose wall via limited or free diffusion. In the second stage, these substances, having penetrated the free space, are adsorbed to the surface of the plasma membrane by some form of binding, while in the third stage the absorbed substances are taken up into the cytoplasm in the process requiring metabolically derived energy.

Zinc is an important element and contribute 49% to agriculture soils and Zinc is essential micronutrient for the nutrition both plants and human. One third of the world population suffer from Zn deficiency. However, deficiency effect of Zinc can be fixed with the foliar fertiliser application towards leaf. The failure of root uptake of zinc can be repair due to chemical constraint such as in alkaline soils because of precipitation, so foliar application can be efficient to prevent that problem (Cakmak, 2008; Cakmak et al., 2010). The foliar applied nutrients absorb in the leaf surface into the underlying plant tissue is unknown (Fernández et al., 2017; Li et al., 2017).

Marschner (2012) indicates that the use of foliar sprays potentially offers advantages like direct application, fast response and no losses. Unfortunately, the 10 criteria mentioned to reach the potential are almost never met. General reasons for failure are poor spraying equipment, improper spray formulation, poor timing, adverse climatic conditions and imbalanced dosing. Fernández et al., (2013) state foliar application should be considered when: Soil conditions limit availability of soil applied nutrients (for example calcium and phosphate fixation in soils of high pH). High loss rates in soil occur (for example rainy season on coarse quartz sandy soil). Delivery to the right organ is impeded (for example calcium and boron to fruit tips). Plant uptake is severely hindered (for example severe root loss after flooding

2.9 Comparison between Foliar fertiliser Application and Broadcast Applications

Soil application of fertilizers is mainly done on the basis of soil tests, whereas foliar nutrient applications are mainly conducted on the basis of visual foliar symptoms or plant tissue tests. Hence, correct diagnosis of nutrient deficiency is fundamental for successful foliar fertilization (Fageria et al. 2009). It is confirmed that, foliar nutrition gives better results if plant cultivation is conducted on soil with optimal pH value and level of mineral nutrients (Szewczuk & Michałojć, 2003).

In case of high nutritional status of plants, additional foliar supplementation of mineral nutrients may increase its leaf concentration to the level of luxury consumption, therefore a non-significant increase of crop yield and its quality would be expected. Whereas, additional foliar application of mineral nutrients could be considered cost-effective if it is conducted to obtain crops biofortfied with micro- and trace elements, that are deficient in human diet living under certain environments (Smoleń 2012). If deficiency of nutrients occurs in plants, its supplementation through foliar application will be more rapid than through soil fertilization. Foliar uptake of mineral nutrients is ranged from 8 to 20 times more efficient than soil application. Nevertheless, such high efficiency is not commonly achieved in agricultural practice.

2.10 Proper time of applying foliar fertiliser

The critical timing of foliar sprays, particularly in regard to growth stage, could be considered critical in relation to the optimum efficacy of the foliar treatment, and more attention should be given to it (Alexander, 1986). The effectiveness of foliar nutrition is affected by numerous endogenous (related to leaf anatomical structure) as well as exogenous (nutrient concentration, soil type, pH) and environmental factors. Simultaneous application of foliar nutrition with plant growth and development biostimulators enables the increase of crop yield and the improvement of its quality. A significant trend in functional food production is plant biofortification with mineral nutrients – mainly Ca, Mg, microelements, and biogenic trace elements.

Foliar nutrition can be used as a method of increasing crop level of these elements. Environmental factors include time of day, humidity, temperature and wind speed influence the physical and biological aspects of foliar applications. Plant tissue permeability is an important factor in absorption of nutrients into the plant: warm, moist and calm conditions favour highest tissue permeability, conditions found most often in the late evening hours, and occasionally in the early morning hours.

2.11 Soil physical properties

Soil moisture plays an important role in terrestrial environment (Vereecken et al. 2008; Robinsonet al. 2008; Seneviratne et al. 2010; Legates et al. 2011). This is because it was influence by weather, climate, plant growth, hydrology and soil ecology (i.e., carbon/nitrogen dynamics, and trace gas emissions). For several decades, the need of intensive and extensive soil moisture information has been recognized (e.g., Robock et al. 2000; Western and Grayson 1998).The key soil process was depended on the soil physical properties that also affect the agronomic potential of a soil.

The size distribution which is soil texture was a composing the solid fraction of the soil (from clay <2 μm to coarse particles >2000 μm) from mineral practices is the most important aspect that determines many other physical properties (infiltration rate) and chemical properties (exchange capacity). Soil structure describes the arrangement of mineral particles and organic matter in the soil, and particularly the arrangement of pores among these particles, and also the stability of this arrangement under external forces such as traffic or rainfall drops. In contrast to texture, soil structure can be substantially modified by soil management.

2.12 Soil pH and nutrient availability

Soil pH has the soil solution that was in equilibrium with protons (H+) retained by soil colloids (oxides, organic matter, clays) is called soil pH. Physicochemical and biological properties were affected by the degree of acidity or alkalinity of a soil. The base saturation with the liming process (soil amendments) can be applied if the acidity of the soil is high. The availability of Mo and P compound were increased, while the solubility is decrease at the low pH and the risk of deficiency of base nutrients (Ca, Mg, and K) increase because of their low content. The microbial activity in soils that can affect many soil process was decreased when the pH extreme such as soil organic matter decomposition. Al is not present at high concentration when concentration in acidic soils is low and affects the rise dispersion of colloids. Poor physical properties, poor structural stability or low permeability occurred when the soil is acidic(Go, 2016).

2.13 Soil Organic Matter

Soil organic matter is a key attribute of soil quality (Larson and Pierce l99l: Doran and Parkin, l994). Soil organic matter is important in maintaining soil tilt, aiding the infiltration of air and water, promotions water retention, reducing erosion and controlling the efficiency and fate of applied pesticide (Gregorich, Carter, Angers, Monreall, & Ellerta, 1994). Living organism, dead, plant litter and roots, decomposable material and biologically active compound was including in soil organic matter.

These compounds have a relatively rapid turnover in soil and are used readily as substrates by soil microorganisms. Humic substances make up a significant portion of the total organic C and N in soil (Anderson 1979). They consist of complex polymeric organic compounds with high molecular weight and are intimately associated with soil inorganic constituents. The complex chemical structure of humic substances makes them more resistant to decomposition than the non-humic materials.

The relative impact of management practices on soil organic C levels will change with soil climate. The assessment of organic C and N as indicators of soil quality should also include consideration of inherent soil properties and site-specific processes (Gregorich, 1994). For example, texture plays an important role in determining the amount of organic matter that may be stabilized in soil. Soils with relatively high clay contents tend to stabilize and retain more organic matter than those with low clay contents (Jenkinson 1977; Ladd et al. 1990). Removal of organic-rich topsoil by erosion is a process that influences the level of organic matter in soil (Voioney et al. 1981; Gregorich and Anderson 1985). Soil redistribution by tillage and water and/or wind erosion can have a major impact on the total amount of soil organic C and N (de Jong and Kachanoski 1988).

2.14 NPK fertiliser

The growth of normal plant mostly depends on element that already have in soil. There are mostly about 16 elements that were required by plants (Acquaah, 2002).Between 16 elements, it has macronutrient that contains nitrogen, phosphorus and potassium (NPK) was important to the growth of plant. This is because the element was needed in the large quantity. NPK are compound fertiliser that has mixture of nitrogen, phosphorus and potassium.

Nitrogen is absorbed via soil in nitrate term (NO_3^-) and ammonium (NH_4^-). The chlorosis in plant can be prevented especially in the mature leaf with the suitable rate of nitrogen (Salisbury and Ross, 1992).Excessive amount of nitrogen can affect the plant leaf have green leaf and the minimum size of root system also effects the ratio of the shoots to roots was high. The least content of nitrogen affects the leaf turn to dark green colour.

Phosphorus usually was absorbed in phosphate monovalent (H2PO4) and divalent anion (HPO). Next, the pH of soil can decides the anion of contents in the soil. Plant that has low content of phosphorus can affects the low growth and low the process of plant to mature. The excessive content of phosphorus affects the increase the growth of roots (Salisbury & Ross, 1992).

Potassium was an activator towards many enzymes that important to photosynthesis and respiration and it also can activate enzyme that was needed to produce protein and starch (Bhandal & Malik, 1988). In dicotyledonous plant, the low content of potassium affects non serious chlorosis. Corn that has low content of potassium have a weak stalk and the roots is easy to attack by root rot organism (Salisbury & Ross, 1992).

2.15 Effects of NPK towards growth

The efficiency of fertiliser used was increasing by the usage of fertiliser compound and the costs are not too expensive. The nitrogen, phosphorus and potassium element were contained in NPK fertilizer which is a compound fertilizer. The nutrient content that needed in the soil was increased with the use of NPK fertiliser and directly used towards plants. Based on Silitonga, Sipayung& Sitorus, 2008, the productions of rice were increased from 0.3 to 1.6 tons /Ha by applying 400 Kg/Ha of NPK fertilisers. Plant height, number of flowers, number of fruit, and weight for red curly chilli plant were also increased with 300 Kg/Ha of NPK fertiliser.

2.16 Biomass production

The interaction between organic fertilizer type and the application mode in the agriculture will affected. The previous study (Diovany *et al.*, 2012), showed that the interaction between the organic fertilizer type and the mode of application in the agriculture will be influenced the fresh and dry weight of plants. The application of NPK at the rate of (4g) is the most effective on increasing the fresh weight of roots and shoots and significantly increased the number of leaves, diameter of stem and length of roots. However, the percentage of water content of the stems and leaves will be increases until the time of flowering but decreases significantly just after the flowering (Afaf, 2012; Sande, 1928). The growth of plants is controlled by their genetic and by several environmental factors, such as water stress and it can be characterized by continuous water loss through transpiration into the atmosphere and by decreased water uptake that caused by reduced soil moisture.

CHAPTER 3

MATERIALS AND METHOD

3.1 Study site

This research was conducted at Universiti Malaysia Kelantan Jeli Campus, Malaysia (5.6990° N, 101.8464°E). The location of the site is shown in Figure 3.1. The amount of annual precipitation from January to December 2017 is 2562 mm and the average temperature is 26.7°C (Google, 2018). This study was conducted in two separate experiments. Experiment 1 was conducted in environmental structure (greenhouse) and experiment 2 was conducted in open field.

As for the experiment 1, poly bag sized 16cm×16cm was used. Green house that sized of 4m ×3m and the height of 2.5 m was used in this experiment to protect from insects and pest. The light intensity of the place is suitable for the plant because it has light cover that can prevent direct exposure to the plant. This is because suitable temperature for Pak Choy to grow is between 15-20°C (Larkcom, J 1991)

As for the experiment 2, the area of 21.6m that consists of eighteen plots was prepared to transplant the Pak Choy. Each of the plots has diameter of 1.0×1.2m. The soil texture of the study area was classified as sandy clay loam.

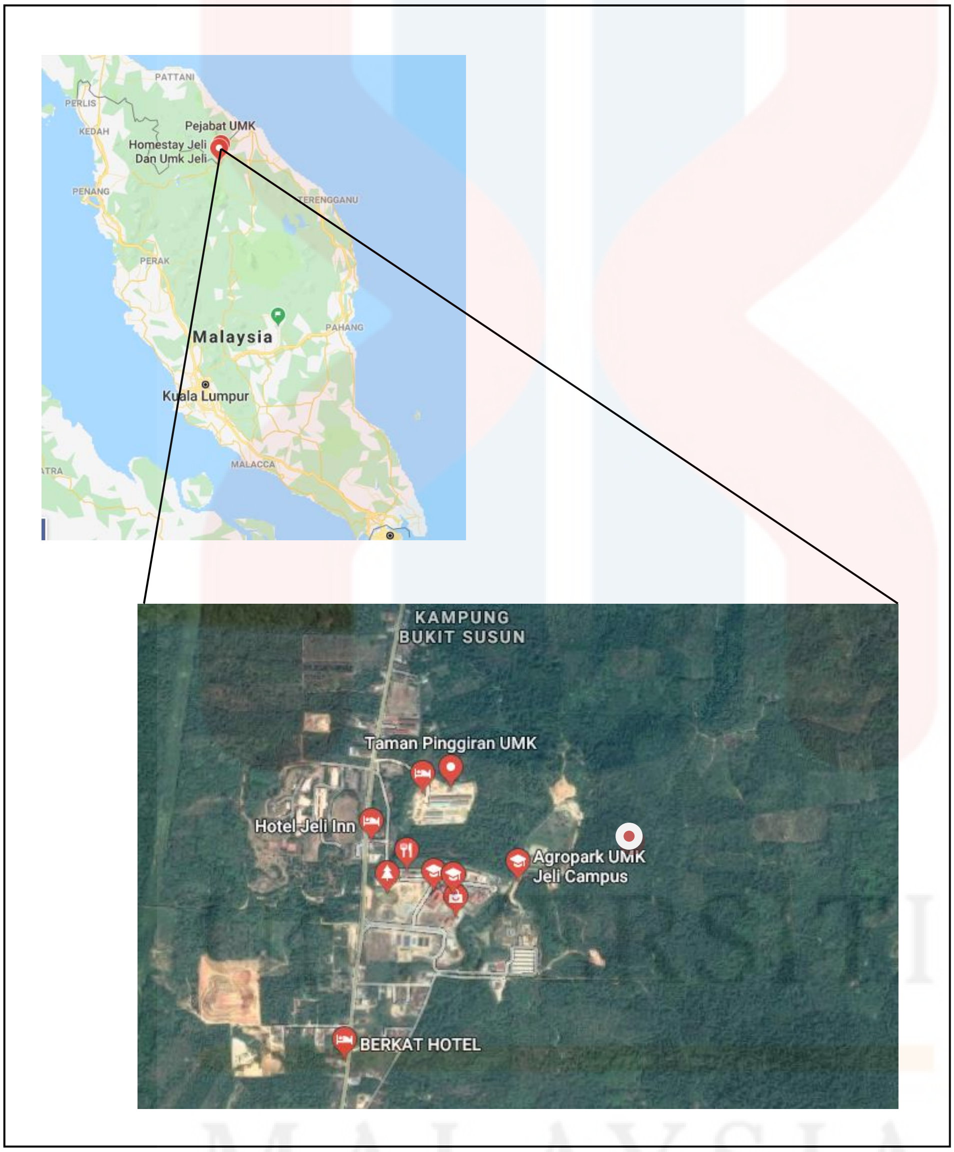
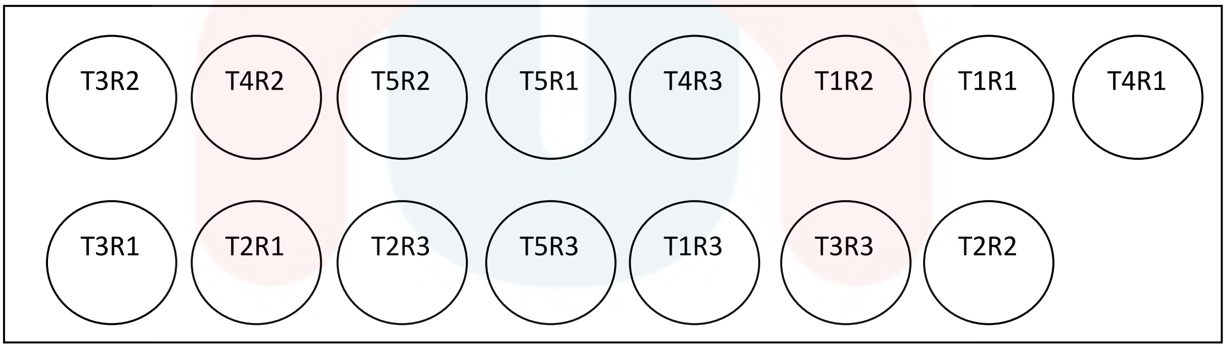


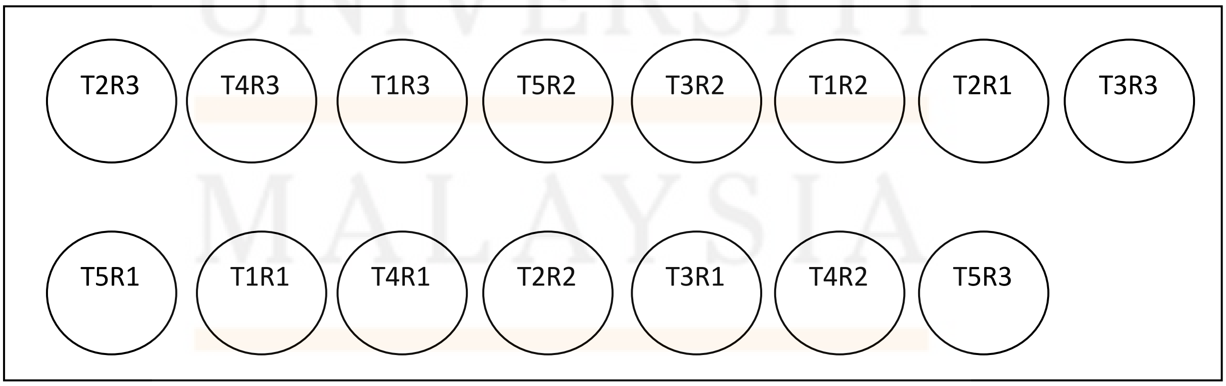
Figure 3.1: The location of study area (Source: Google, GADM, 2018

3.2 Experimental Design

Figure 3.2 shows the experimental design that was used in experiment 1 is Completely Randomized Design (CRD). These study use two types of fertilizer such as Bokashi and Monosodium Glutamate to observe the best rate of both fertilizer. There are 5 treatments with 3 replication and was conducted in greenhouse that have benches. Figure 3.1 shows bench 1 is the arrangement of MSG and bench 2 is the arrangement of Bokashi. The rates of Bokashi were shown in Table 3.1 and the rates of MSG were shown in table 3.2.



Bench 2



Bench 1

Figure 3.2: Arrangement of treatment of Bokashi (bench 1) and MSG (bench 2)

T = Treatment

R = Replication

Table 3.1: The rates of Bokashi

Treatment (Bokashi)	Rate of Bokashi (g)
Treatment 1	0
Treatment 2	5
Treatment 3	10
Treatment 4	20
Treatment 5	50

Table 3.2: The rates of Monosodium Glutamate

Treatment (Monosodium Glutamate)	Rate of MSG
Treatment 1	0g + 1L of water
Treatment 2	1g + 1L of water
Treatment 3	2g + 1L of water
Treatment 4	3g + 1L of water
Treatment 5	4g + 1L of water

Figure 3.3 shows second experiment that was conducted in open field. It use 3×2 factorial experiment and was arranged in Completely Randomized Block Design (CRBD). The defining feature of the CRBD is that each block sees each treatment exactly once. Three replications also will be used in this experiment. The Pak Choy seed was planted 20cm apart each other and 20cm between the plants. Each plot had 20 plants of Pak Choy. The rates of Bokashi and MSG were shown in Table 3.3.

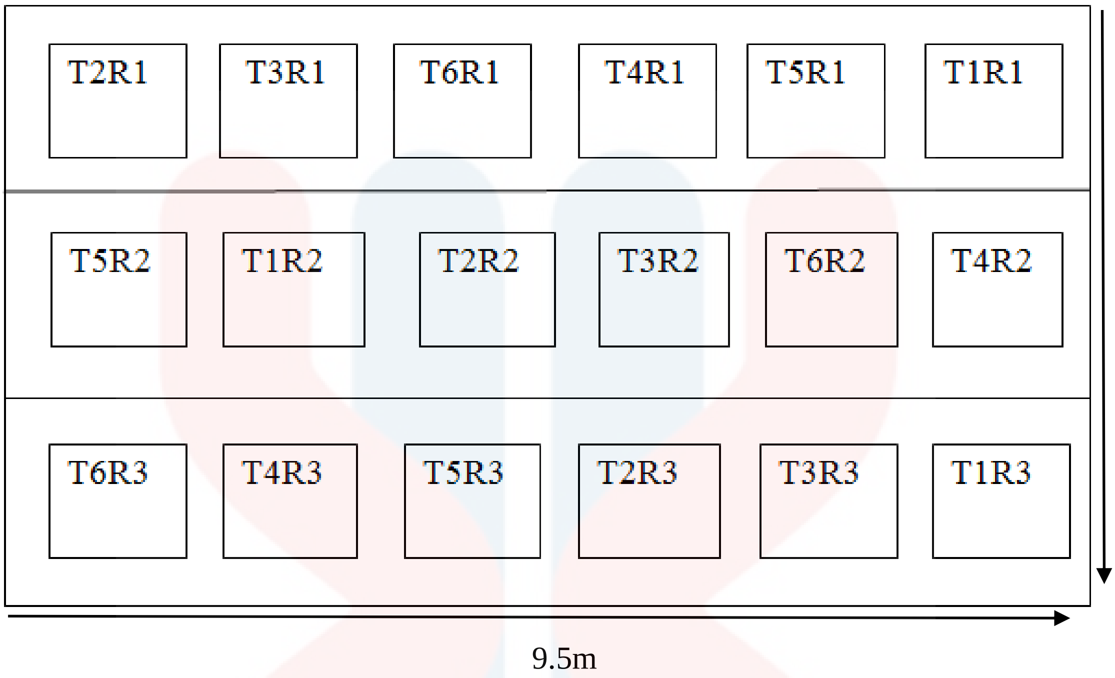


Figure 3.3: Experiment Layout for Experiment 2

T = Treatment

R = Replication

Table 3.3: The rates of Bokashi and MSG

Treatment (Bokashi + MSG)	**Rate of Bokashi + MSG**
Treatment 1	0g + 2g/1L
Treatment 2	0g + 3g/1L
Treatment 3	240g + 2g/1L
Treatment 4	240 g +3g/1L
Treatment 5	1200g+ 2g/1L
Treatment 6	1200g+3g/1L.

3.3 Preparation of poly bag

As for the preparation of media, 10kg of topsoil was put in each of the poly bag. Bokashi fertiliser was applied 7 days before transplant. The Bokashi was mixed with the soil. There are 15 polybags that was applied with Bokashi as fertiliser. There also 15 polybags for planting Pak Choy with applying MSG as foliar fertiliser.

3.4 Preparation of planting bed

The area of planting bed was cleared by using tractor. The land was sow to lose the soil compaction for better absorption of nutrient towards the soil. It can also enhance the performance of the soil. Bokashi fertiliser was applied seven days before transplanting. The Bokashi was mixed with the soil. The silver shine was used to cover from the leaching of Bokashi because of the rainfall.

3.5 Preparation of seedling for poly bag

Two seedling trays were needed to prepare 30 seedlings. Peat moss was put in the tray as the media. Two seeds of Pak Choy was put in each of the holes was for germination. The seeds were germinated and were ready to transplant after 10-15days. The seed was watered two times per day in the morning and evening.

3.6 Preparation of seedling for planting bed

The mixture of compost and peat moss were being used in sowing the seed in the ratio of 1:1. The seed was sown in the bed size 1.2m×1m with the broadcasting method. The seed bed was covered with plastic to enhance the growth of Pak Choy. This is because it helps to conserve the moisture of the soil. After the leaf was appeared about 3 days, the plastic was open to allow the plant to get sunlight.

3.7 Transplant of Pak Choy

The seed were removed from seedling tray and were transplant into the polybag. The polybag were flushed with water once the seed was transferred. For the experiment at the open field, the seedlings were transplant on the seed bed with the distance of 20cm×20cm. This is important to prevent the competition among the plants.The plant was recommended to be harvested after 50-60 days from sowing or 30-40 days from transplanting (Larkcom,2007).

3.8 Frequency of fertiliser applied

Bokashi fertiliser was applied seven days before Pak Choy transplantation. The fertiliser was applied using banding method which was applied between the rows of Pak Choy. The fertiliser was applied at the furrow of 2 inches to the side and 2 inches deeper than and seed furrow. The, the fertiliser was covered by the soil. This is to prevent the leaching because of rainfall. Every two weeks, Bokashi fertiliser also must be applied with the alternation of N-P-K fertiliser with the rate of 400g/hectare. The calculation was made and the optimum rate of using N-P-K was scaled down to get actual rate which is 2.2g/polybag.

3.9 Preparation of MSG dilution

MSG was being dilute with 1000 mL of distilled water. The suitable rate of MSG by using the optimum rate that was used is 15g/tan. After the calculation was being made and was scaled down the actual rate is 3g. The application of MSG was applied by spraying method. The solution of nutrient was sprayed at the leaf surface. The MSG liquid was applied 2 times per week and the dilution was being finished in one week.

3.10 General Maintenance

The plant was watered twice per day. This is because water is one of the major factors and required for performance of plant growth. Irrigation was also important to increase the growth of plant. The unwanted plant also was thrown away. This is because weeding can reduce competition with other plants for light, soil water, and soil nutrients and also important part of silvicultural treatments in the early establishment phase (Wagner Dacosta et al. 2011). The microclimate below the plants also can be altered. Weeding process also can help the soil loose so it will cause the water infiltration increase and the roots of the cultivated plants also increase.

3.11 Parameters Measures

The duration of the experiment will be 6 weeks. The estimation time taken for the seed ready to transplant is 2 weeks and another 4 weeks were for data collection. The Pak Choy was harvested between 30 - 40 days after planting. The parameters of the growth of Pak Choy were observed and the data was taken.

3.11.1 Growth performance

The parameter was taken weekly**.** The data of height of the plant and root morphology was taken using measuring tape. As for the root parameter, the spade was used to remove the roots from the soil. The roots were cleaned and the residual soil was removed. The total number of the leaf was manually counted. Venire calliper was used in identifying the diameter of branches. The reading of chlorophyll content of leaves was directly taken using SPAD meter. During the last decade, the portable SPAD-502 chlorophyll meter apparatus has been widely used for the non destructive, in vivo, fast determination of plant leaf TCHL instead of the destructive, in vitro and time consuming colorimetric methods (Papasavvas, 2008)

3.11.2 Determination Pak Choy yield

At the end of this study, the Pak Choy was harvested. As for the plant fresh weight, the roots was separated and by using balance, the data of yield per plot was taken. The fresh weight of roots was using electronic balance. As for determining plant and roots biomass, the plant and roots was placed in an oven at 55°C of temperature for at least 12 hours. Then the weight of the sample was observed using electronic balance and the data was recorded.

3.11.3 Soil analysis

The soil was being observed and the data was taken. Soil temperature and soil pH were measured on all 10 poly bags and 6 plots directly in the soil weekly. The sampling period was taken and a complete set of treatment combinations (one block) were measured followed by another until all 6 blocks were sampled. For, soil experiment, the soil was conserved first. The soil sample was oven dry at 105°C at least 24 hours. This is to conserve the nutrient of the soil. The soil was crush using mortar and pestle. Then, the soil sample was sieved through 2mm sieved and was put in the zip bag. The sample was labelled according to respective treatments and replication.

Most humic substances are about 50-58% organic C, which is usually determined by either wet or dry oxidation methods (Tiessen and Moir 1993). The CO2 was converted from organic C by dry oxidation (combustion) methods that burn the organic matter in air or oxygen in a furnace. Organic matter content and total carbon can be determined by using furnace in the temperature of 550°C at least 8 hours.

Equation (3.1) shows total carbon percentage where TC is total carbon. Equation (3.2) shows percent total organic carbon content.

Total Carbon Percentage

(TC) = W (g)

Carbon (g)

TC (%) = Where: W (g) = dry sediment analysis weight (g) (3.1)

Percent total organic carbon content

$$\text{Organic Carbon (g) TOC (\%)} = \frac{\text{Organic Carbon (g)}}{\text{W (g)}} \qquad (3.2)$$

(Bernard, Bernard, & Brooks, 2004)

3.12 Statistical Analysis

Service Product Statistical Solution (SPSS) version 16.0 was used through one-way analysis of variance (ANOVA) to compute the data. The significance different between treatments and the interactions between treatments were detected by using SPSS. Duncan's Multiple Range Test (DMNRT) will be used to separate the means among the treatments.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 The effect of Bokashi towards the height of the plant, diameter of branch number of leaves and chlorophyll content

Table 4.1 shows the rate of Bokashi in treatment 3 results the mean height of 16.19cm and was significantly different with the control but not different with other treatments. Treatment 3 also shows the largest diameter of branch which is 1.58cm compared to other treatment but it does not significantly different with other treatment. Treatment 3 shows the highest number of leaves which is 9.83 and does not significantly different with other treatments

Overall, the conclusion that can be made is Bokashi with the rate of 2 tonne/ hectare shows the highest height and was the optimum rate of Bokashi. The result was same as a study (Muzayyanah, 2010) that shows 2 tonne/hectare impacts the highest result among the treatments.

The result shows there are no significant differences towards chlorophyll content between all the treatments. But Bokashi in treatment 3 has the highest mean of chlorophyll content which is 37.87. The high of chlorophyll content defined that photosynthesis rate is high. This is so important because photosynthesis can assimilate and transfer light energy by using photosynthetic pigments. So, the photosynthetic efficiency affected by the pigments contents. The least of chlorophyll content is in control treatment which 35.17.

The application of Bokashi also can give significant impact (Hamzah, 2007). This is because Bokashi that come from manure have nutrient and organic matter which can improve the physical, chemical and biology of soil. The better available nutrient in the soil, soil structure and soil aeration impact the growth of the plant and the growth of roots.

Table 4.1 Mean value of Bokashi on growth performance of *Brassica Chinensis*

Treatment	Height of the plant (cm)	Diameter of Branch (cm)	Number of leaves	Chlorophyll content
Treatment 1 (control)	10.70 ± 6.34^{b}	1.16 ± 1.04^{a}	7.92 ± 2.11^{ab}	35.17 ± 5.92^{a}
Treatment 2	13.70 ± 6.13^{ab}	1.17 ± 1.08^{a}	9.67 ± 2.18^{ab}	37.63 ± 10.51^{a}
Treatment 3	16.19 ± 6.73^{a}	1.58 ± 1.32^{a}	9.83 ± 2.29^{a}	37.87 ± 14.13^{a}
Treatment 4	15.13 ± 4.96^{ab}	1.46 ± 1.27^{a}	9.25 ± 1.49^{a}	35.97 ± 6.53^{a}
Treatment 5	13.40 ± 4.81^{ab}	1.24 ± 1.04^{a}	8.33 ± 1.50^{ab}	36.03 ± 6.10^{a}

The same superscript letters in a column are not significantly different at the level of 0.05

4.2 The effect of MSG towards the height of the plant, diameter of branch number of leaves and chlorophyll content

Table 4.2 shows treatment 3 impacts the highest height of the Pak Choy which is 12.3cm. However there are no significant differences between all the treatments. According to Pratiwi and Garsetiasih (2007), the most needed elements of plants are nitrogen in MSG that can stimulate plant growth, branches, stems and leaves. The formation of proteins, fats and various organic compounds needed microscopically N elements. So, when the MSG used to water the plant, it can make the plant grow quickly and leaves become denser.

Table 4.2 Mean value of MSG on growth performance of *Brassica chinensis*

Treatment	Height of the plant (cm)	Diameter of Branch (cm)	Number of leaves	Chlorophyll content
Treatment 1 (control)	11.50 ± 4.92[a]	0.54± 0.41[a]	6.63 ± 3.56[a]	34.52 ± 4.95[a]
Treatment 2	12.21 ± 5.40[a]	0.76 ±0.63[a]	7.25 ± 1.36[a]	35.07± 7.53[a]
Treatment 3	12.30 ± 4.91[a]	0.78 ± 0.62[a]	8.41 ± 1.88[a]	37.70± 5.38[a]
Treatment 4	10.25 ± 4.46[a]	0.73 ±0.61[a]	7.58 ± 1.37[a]	34.68 ±5.87[a]
Treatment 5	11.32 ± 4.38[a]	0.70 ± 0.54[a]	8.25 ± 2.22[a]	36.83± 6.27[a]

The same superscript letters in a column are not significantly different at the level of 0.05

The height of the plant of treatment 4 and treatment 5 was decrease because of the concentration of MSG was applied overdose. This result same as observation by Gresinta, (2015) that stated that optimum dosage of *Arachishypogaea is* 6g/tonne,and if the dose increase so the height of the plant will decrease. Based on Gresinta (2015), the solution of MSG affects the height of the plant increase compared to the control. The liquid applications of MSG also give better absorption and increase the plant growth.

However after reach cumulative, plant growth decrease. This happens because plants experience Fe and Al poisoning.

Treatment 3 shows the highest mean of diameter of the branch which is 0.78cm. However, it has differences compare to the control. The number of leaves shows the highest mean in treatment 3 and also has differences with control. Treatment 1 have the lowest chlorophyll content which shows MSG as foliar application can increase the chlorophyll content of Pak Choy. The highest chlorophyll content shows in treatment 3 which is 37.7.

4.3 Effect of Bokashi towards fresh weight and dry weight of plants

Based on Table 4.3, the fresh and dry weight biomass production of *Brassica chinensis* plants were highest in treatment 3 and was significantly different with other treatment which is 430.00g and 0.1150g respectively. The lowest mean value of fresh weight and dry weight in Bokashi which are in treatment 1 (23.67g and 0.0487) respectively.

The interaction between organic fertiliser and the mode of application will influence the fresh and dry weight of the plant (Diovany *et al*., 2012). According to Ziaohou, Min, Ping, & Weiling, (2008), by the use of EM, the yield can be increased and the quality was being improved and plant nutrients can be increased or direct benefit on plant growth, health and protection.

The application of Bokashi increased the production of tomatoes. The same result also was shown towards tomatoes (Togun & Akanbi, 2003; Neliyati, 2006), beans (Koesrini & William, 2009), onion (Mayun, 2007), potatoes (Danilchenko et al., 2005), chilli (Sutari et al., 2003) and leafy vegetables (Iskandar, 2003). This is because the application of Bokashi can improve biology, physical and chemical characteristics of soil. Organic matter can improve the elongation of roots deeper in the soil and the plant can absorb nutrients and large amount of water (Gonzalez & Cooperband, 2002).

Table 4.3Mean value of Bokashi on plant fresh weight (g) and plant dry weight (g) of *Brassica chinensis*

Treatment	Plant fresh weight (g)	Plant dry weight (g)
Treatment 1	231.67±10.408^{d}	0.0487±0.0036^{d}
Treatment 2	278.00±31.927^{c}	0.0540±0.0021^{c}
Treatment 3	430.00±36.055^{a}	0.1150±0.0010^{a}
Treatment 4	356.67±27.537^{d}	0.0670±0.0010^{b}
Treatment 5	300.67±14.140^{b}	0.0545±0.0010^{c}

The same superscript letters in a column are not significantly different at the level of 0.05

4.4 Effect of MSG towards fresh weight and dry weight of plants

Based on table 4.4, treatment 3 has the highest fresh weight which is 128.00g but, it show no significant different with other treatments. However, treatment 4 shows the highest dry weight which is 0.048g and show significant difference with treatment 5. Treatment 5 have the low dry weight which is 0.043 compared to control which is 0.044. This show that excessive usage of MSG can decrease the growth performance and worst than not applying MSG

Table 4.4 Mean value of MSG on plant fresh weight (g) and plant dry weight (g) of *Brassica chinensis*

Treatment	Plant fresh weight (g)	Plant dry weight (g)
Treatment 1	83.33±46.458[a]	0.044[bc]±0.0013[bc]
Treatment 2	105.00±25.980[a]	0.045[bc]±0.0010[bc]
Treatment 3	128.00±44.190[a]	0.046[ab]±0.0014[ab]
Treatment 4	102.50±15.546[a]	0.048[a]±0.0010[a]
Treatment 5	85.00±77.782[a]	0.043[c]±0.0010[c]

The same superscript letters in a column are not significantly different at the level of 0.05

4.5 Effects of Bokashi on fresh weight and dry weight of roots

Table 4.5 shows the fresh weight biomass productions of the roots of *Brassica chinensis* that were applied by Bokashi were highest in Treatment 4 which is 12.33gand shows significant different with other treatment. Treatment 4 also has high value of roots dry weight however it shows no significant different compared to treatment 3 and treatment 5.

The result indicate that in Bokashi have the highest mean value of fresh and dry weight is treatment 4. The increased root dry weight might be due to the good soil condition for root penetration spread the water and the moisture content that caused by the uncertain whether that affect to plants growth. According to the Chaukiyal, (2013), the root biomass was higher than other nitrogen treatments in winter and summer season.

Table 4.5 Mean value of Bokashi on roots fresh weight (g) and roots dry weight (g) of *Brassica chinensis*

Treatment	Roots fresh weight (g)	Roots dry weight (g)
Treatment 1	9.51± 0.392^{c}	3.39 ± 0.476^{b}
Treatment 2	11.25± 0.890^{b}	4.55± 1.452^{b}
Treatment 3	11.79± 0.106^{b}	6.16± 0.255^{a}
Treatment 4	12.33± 1.162^{a}	7.08 ± 0.629^{a}
Treatment 5	12.18± 0.650^{b}	6.70 ± 0.200^{a}

The same superscript letters in a column are not significantly different at the level of 0.05 level

4.6 Effects of MSG on fresh weight and dry weight of roots

Based on table 4.6, treatment 4 shows the highest mean of roots fresh weight is 5.33g and has significant difference with treatment 3 and control. However, treatment 5 shows the highest mean of dry weight which is 2.816g. It also shows significant differences with all the treatments.

Table 4.6 Mean value of MSG on roots fresh weight (g) and roots dry weight (g) of *Brassica chinensis*

Treatment	Roots fresh weight (g)	Roots dry weight (g)
Treatment 1	3.29 ± 0.198^{c}	0.646 ± 0.0.31^{e}
Treatment 2	4.75 ± 0.413^{ab}	1.337± 0.397^{d}
Treatment 3	4.11 ± 0.289^{b}	1.560± 0.197^{c}
Treatment 4	5.33 ± 0.409^{a}	2.330 ± 0.165^{b}
Treatment 5	4.74± 0.525^{ab}	2.816± 0.163^{a}

The same superscript letters in a column are not significantly different at the level of 0.05

4.7 Effects of Bokashi and MSG towards soil organic matter and soil carbon

Based on Table 4.7, the value of soil organic matter and soil carbon was decrease in all treatments after applying Bokashi and MSG. Soil organic matter and soil carbon also depend on texture. Texture is one of the important factors that determine the amount of organic matter that can stabilize in soil. Organic matter can be retained and stabilize with high clay contents compared to low clay contents (Jenkinson 1977; Ladd et al. 1990).The wind erosion and soil tillage also can have major impact on the total amount of soil organic (de Jong and Kachanoski 1988).From the soil texture analysis using hydrometer the result shown is 40% silt, 40% sand and 20% clay. So, the low organic matter content and low soil carbon after applying fertiliser may because of soil that have low content of clay.

Table 4.7 Value of Bokashi and Monosodium Glutamate on soil organic matter and soil carbon of *Brassica chinensis*

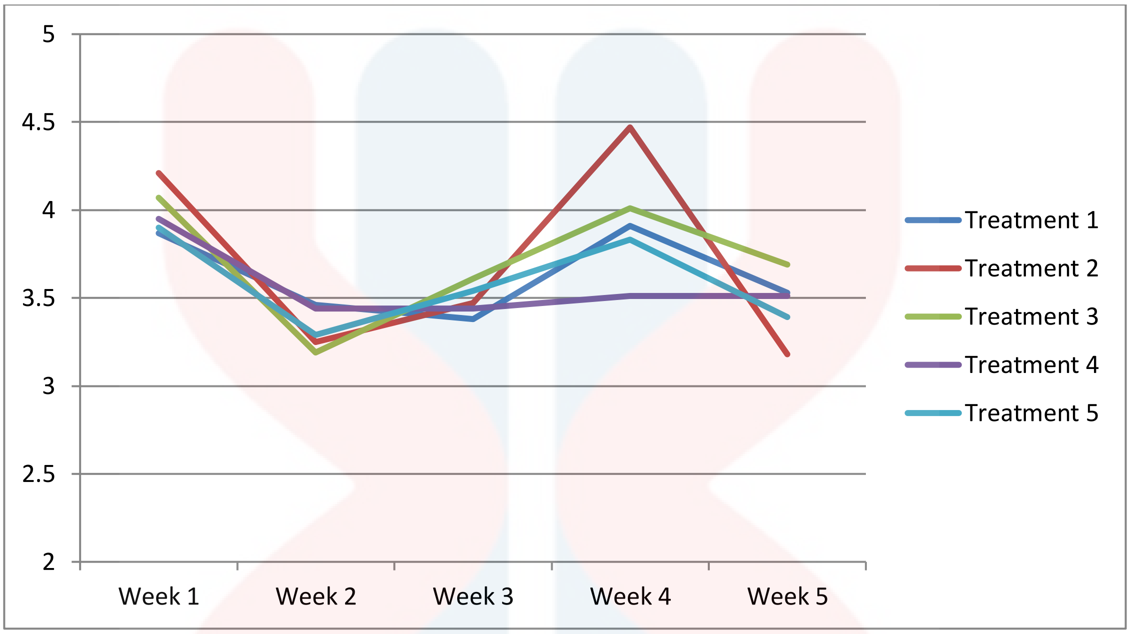
Treatment	Soil organic matter (%) Before	Soil organic matter(%) After	Soil carbon Before	Soil carbon After
Bokashi, 0g	2.98	0.79	1.733	0.46
Bokashi, 5g	2.76	0.4	1.605	0.23
Bokashi , 10g	2.79	0.4	1.618	0.23
Bokashi, 20g	5.87	0.79	3.4	0.46
Bokashi, 50g	6.53	0.996	1.79	0.578
Monosodium Glutamate, 0g + 1 L water	5.77	0.398	3.35	0.231
Monosodium Glutamate, 1g + 1 L water	6.12	0.990	3.55	0.574
Monosodium Glutamate, 2g + 1 L water	5.33	2.0	3.09	1.16
Monosodium Glutamate, 3g + 1 L water	6.73	0.797	3.9	0.462
Monosodium Glutamate, 4g + 1 L water	4.96	1.18	2.88	0.689

4.8 Effects of Bokashi and MSG towards Soil pH

Figure 4.1 show there was no difference among the treatment in soil pH with the application of Bokashi. The differences in week 1 among the treatments range between pH of 3.9 - 4.2. While in week 2 the difference between treatments was 3.2-3.5. In week 3, the results shows difference between the treatments which is 3.4 – 3.7. Treatment 2 shows the highest soil pH which is 4.45. Treatment 2 has the lowest pH of soil which is 3.19 and has the differences of 0.5 pH.

This is because the soil pH decreases in warm and humid environment and was called soil acidification because of leaching. The soil mineral weathering and leaching was control by temperature and rainfall. The result shows the soil pH low when the temperature is high. Soil texture also can affect soil pH. The texture of the study site is sandy loam which has the low content of clay. The rise and drop in pH soil are able to resist in clay soil because it has great buffer content than sandy soil. Sandy soils commonly have low organic matter content, resulting in a low buffering capacity, high rates of water percolation and infiltration making them more acidic.

pH

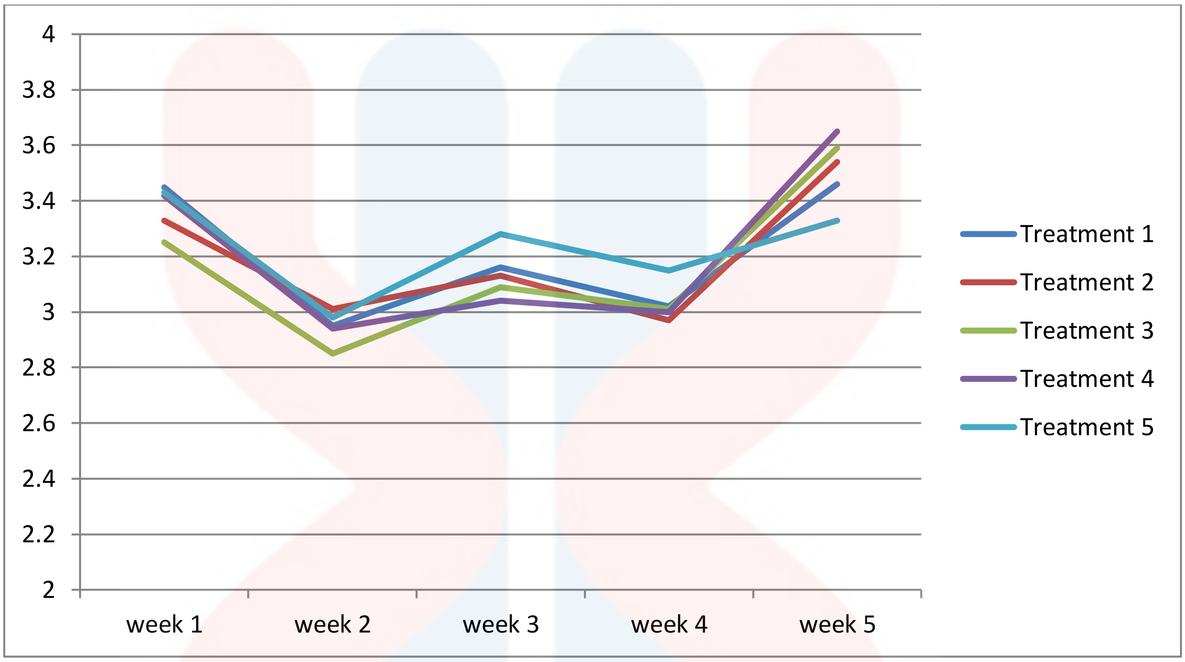


Treatment 1= Bokashi 0g, treatment 2= Bokashi 5g, treatment 3= Bokashi 10g, treatment 4= Bokashi 20g, treatment 5= Bokashi 50g

Figure 4.1 The results of soil pH between week and treatment with the application of Bokashi.

Figure 4.2 shows soil pH that was applied by MSG treatments. Treatment 3 shows the lowest value in week 1 which is 3.22, while the highest pH is treatment 4 which is 3.46. The difference among the treatment is 0.2 which very least different among the treatments. Treatment 2 is the highest pH which is 3.0 but the differences among the treatment is 0.18. In week 3 the highest pH of the soil is 3.3 in treatment 5 and the differences is 0.3. Treatment 5 has the highest soil pH which is 3.18 and the difference among the treatments is 1.8. For the final week, treatment 1 has the highest reading of soil pH which is 3.7 and the differences among the treatments were 0.4.

pH



Treatment 1= MSG 0g/1L, treatment 2= MSG 1g/1L, treatment 3= MSG 2g/1L, treatment 4= MSG 3g/1L, treatment 5= MSG 4g/1L

Figure 4.2 The result of soil pH between week and treatment with application of Monosodium Glutamate (MSG).

4.9 The effect of the combination of Bokashi and MSG towards fresh weight and dry weight of plants

Table 4.8 shows Bokashi treatment 6 has the highest mean of fresh weight which is 2800g. There are no significant differences between the treatments. The least fresh weight is treatment 3 which is 2155g. This is because Bokashi fertiliser was not applied, so it does not have high fresh weight due to least organic matter and decompose.

The highest mean of plant dry weight is treatment 6 which is 0.0736g and has difference with treatment 5 which is 0.0595g. This shows the least mean average of dry weight is 0.0436g which is treatment 1.

Table 4.8 Fresh weight (g) and dry weight (g) of *Brassica chinensis* that was applied by the combination of Bokashi and MSG

Treatment	Fresh weight (g)	Dry weight (g)
Treatment 1	2200 ± 476.96[a]	0.0436 ± 0.0015[a]
Treatment 2	2275 ± 403.12[a]	0.0453 ± 0.0042[ab]
Treatment 3	2155 ± 289.91[a]	0.0456 ± 0.0288[ab]
Treatment 4	2250 ± 638.36[a]	0.0497 ± 0.0054[ab]
Treatment 5	2416 ± 251.66[a]	0.0595 ± 0.0007[ab]
Treatment 6	2800 ± 650.00[a]	0.0736 ± 0.0344[b]

The same superscript letters in a column are not significantly different at the level of 0.05

4.10 The effect of the combination of Bokashi and MSG towards fresh weight and dry weight of roots

Table 4.9 shows the highest mean of root dry weight is treatment 6 which is 7.19g. There are no significant differences among the treatments. The least weight of fresh roots is 5.81g which is treatment 1.

The highest mean of root fresh weight is 31.34 g in treatment 6. There was no significant difference between the treatments. This shows the roots fresh weight of Pak Choy not really affected by the different rate of combination of MSG and Bokashi

Table 4.9 Fresh weight (g) and dry weight of roots (g) that was applied by the combination of Bokashi and MSG

Treatment	Fresh weight of roots (g)	Dry weight of roots (g)
Treatment 1	14.29 ±1.169[a]	5.81 ±0.922[a]
Treatment 2	20.56 ±7.638[a]	5.93 ±.499[a]
Treatment 3	25.40 ±2.263[a]	6.10 ±.222[a]
Treatment 4	28.15 ±5.095[a]	6.58 ±0.893[a]
Treatment 5	30.91 ±4.773[a]	6.83 ±0.633[a]
Treatment 6	31.34 ±19.165[a]	7.19 ±0.975[a]

The same superscript letters in a column are not significantly different at the level of 0.05

4.11 The effect of the combination of Bokashi and MSG towards soil organic matter and soil carbon

Table 4.10 shows all the treatments decrease in organic matter because of the nutrient uptake by the plant. The highest soil organic matter content is treatment 1 which is 7.1 and it is the optimum rate that suitable to agriculture which is 6-7. However, treatment 1 has a high total organic matter that was lose. This may because of the Bokashi fertiliser was not applied in treatment 1. The least of organic matter content that lose is in treatment 6. This is because the Bokashi fertiliser rate is the highest. So, the organic matter content was the highest among the treatments.

Table 4.10 Value of the combination of Bokashi and MSG on soil organic matter and soil carbon of *Brassica chinensis*

Treatment	Soil organic matter (%) Before	Soil organic matter(%) After	Soil carbon Before	Soil carbon After
Treatment 1	7.1	2.19	4.12	1.273
Treatment 2	6.19	2.82	3.59	1.636
Treatment 3	7.59	3.48	4.4	2.018
Treatment 4	7.16	4.20	4.15	2.436
Treatment 5	5.6	3.98	3.25	2.308
Treatment 6	6.37	5.35	3.69	3.103

4.12 The interaction between Bokashi and MSG towards height of the plant

Based on Figure 4.3 there are interaction between Bokashi and MSG. The interaction appear between 0g to240g of Bokashi. There also interaction between 240g to 1200g of Bokashi. Bokashi of 240g with MSG 3g have the lowest height of the palnt. While MSG with 3g/1L shows the best height of the plant. when the rate of Bokashi increase, MSG 3g/1L also shows increasing in the height of the plant. MSG 2g/1L decrease the heigth of the plant when Bokashi rate increase.

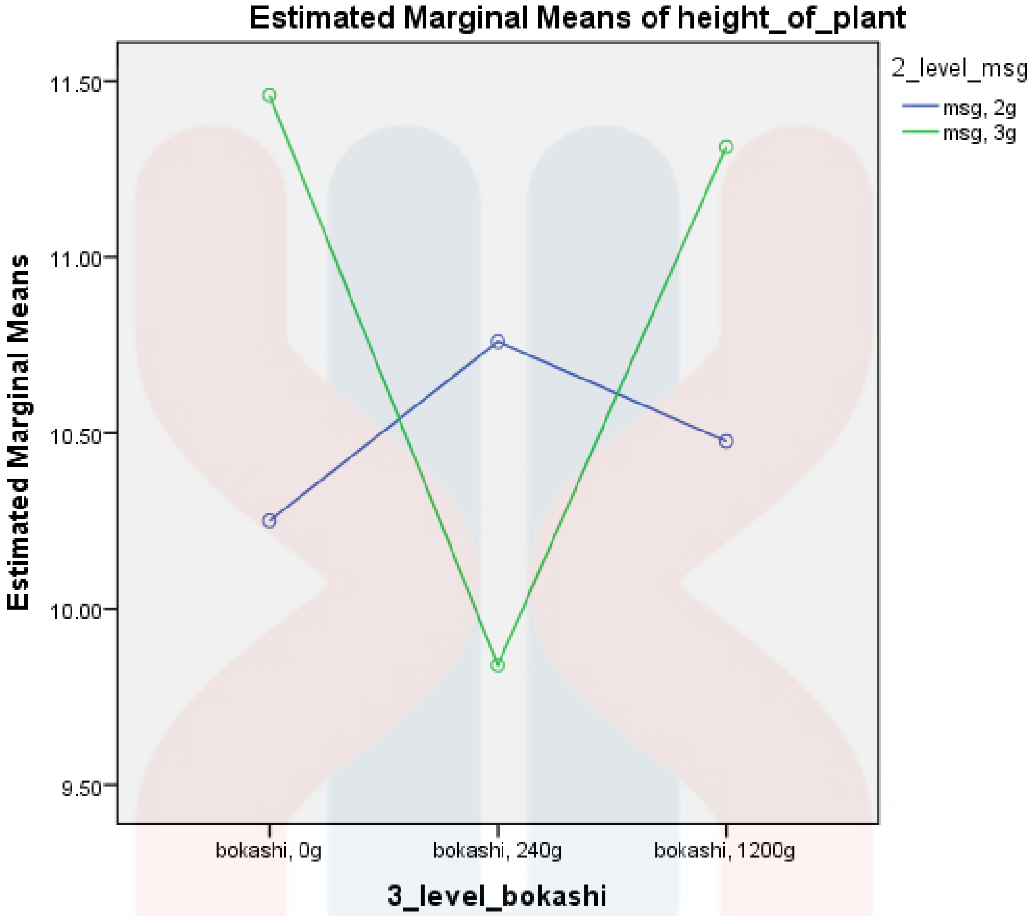


Figure 4.3. The graphline interaction between Bokashi and MSG towards height of the plant

4.13 The interaction between Bokashi and MSG towads the diameter of branch

Figure 4.4 shows there are no interaction between Bokashi and MSG towards the diameter of the branch. Both of the treatment shows increasing of branch diameter when the rate of Bokashi increase. The most higher value is the combination of 3g/1L of MSG and 1200g of Bokashi. This shows MSG with 3g/1L with the combination of 1200g of Bokashi increase the diameter of the branch compared to MSG with 2g/1L.

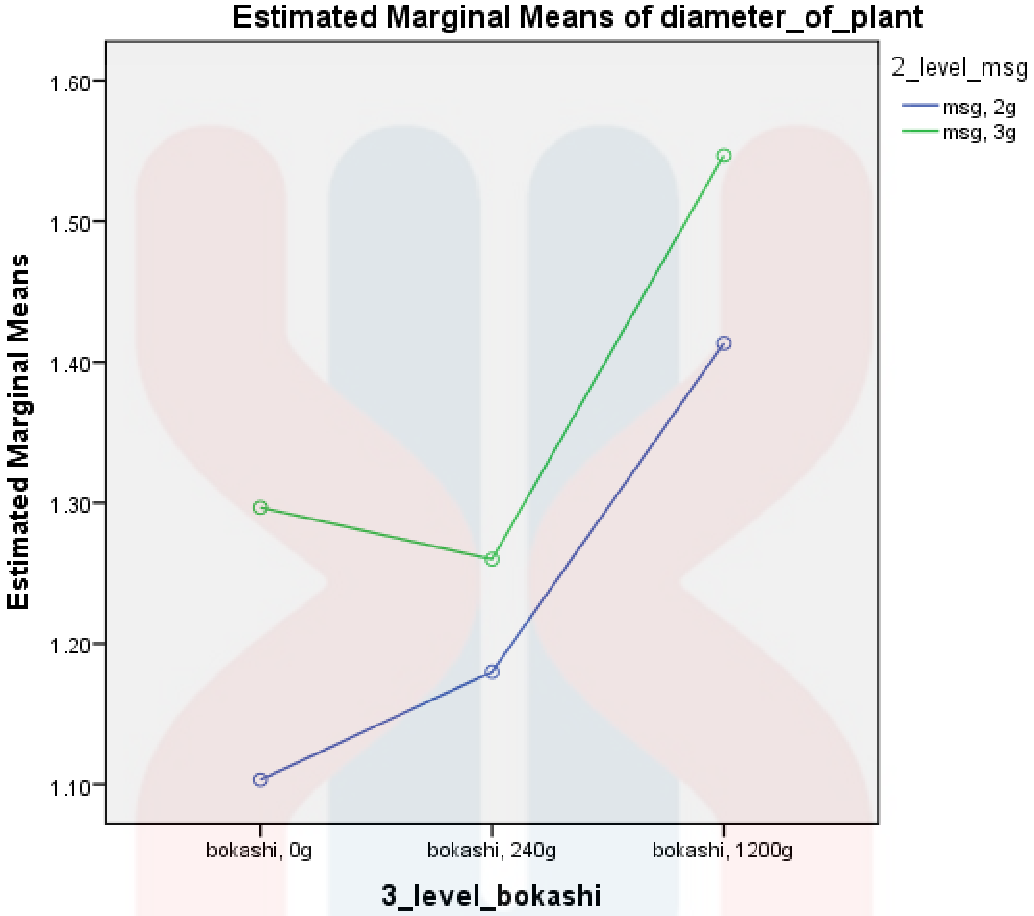


Figure 4.4. The graphline of interaction between Bokashi and MSG towads the diameter of branch

4.14 The interactions between Bokashi and MSG towards number of leaf

Figure 4.5 shows 2g/1L and 3g/1L of MSG have interaction at the range of 240g to 1200g of Bokashi. This means the number of leaf is the same if the application of Bokashi 240g was applied with 2g/1L and 3g/1L. But, when 2g/1L of MSG was applied with 1200g, the number of leaf was decreasing. MSG level of 3g/1L do increase the number of the plant when it is combine with 1200g of Bokashi. The highest number of leaf number was applied by MSG of 2g/1L without Bokashi. This shows MSG of 2g/1L alone does effects the number of the plant.

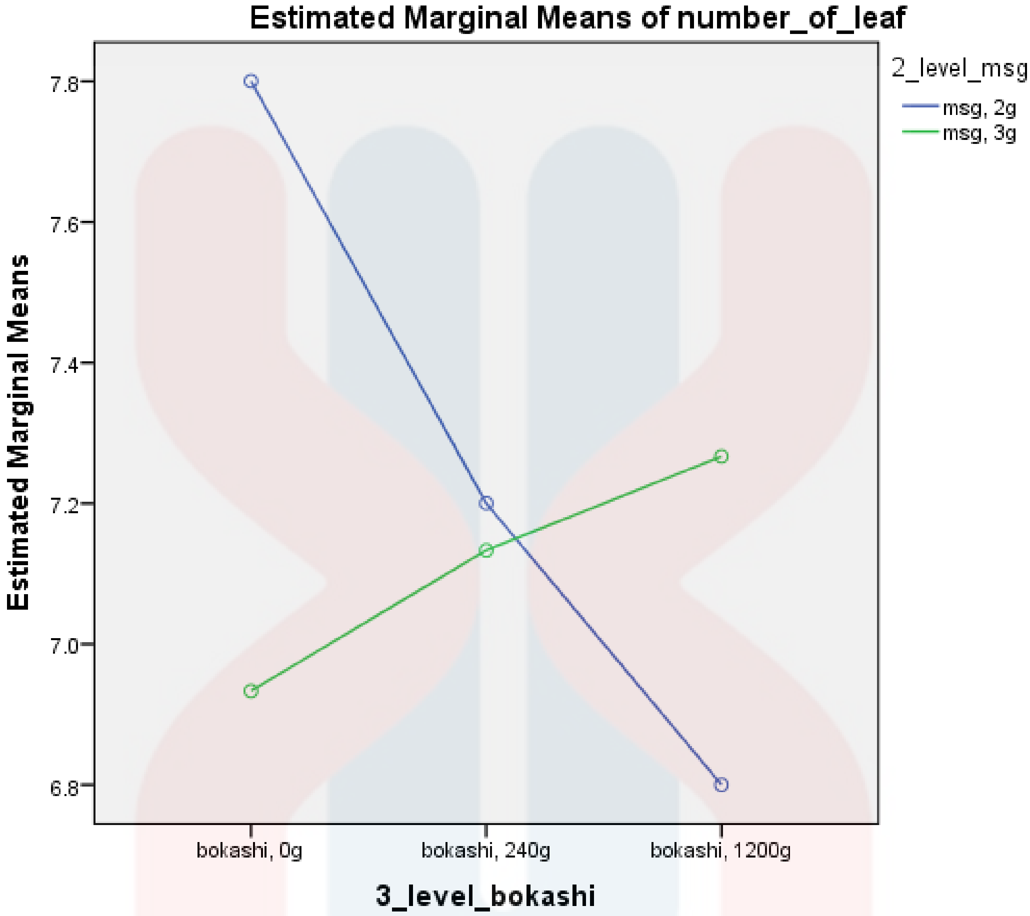


Figure 4.5. The graphline of interactions between Bokashi and MSG towards number of leaf

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusions

Bokashi applications significantly increased the growth performance of Pak Choy yield during 6week cultivation. Based on the results from the present study, these are the following conclusions that can be drawn. Firstly, Bokashi rate of 2 tonne/ hectare has a significant difference with control and can increase the yield of the plant and growth performance of the plant such as height of the plant and number of leaves. Secondly, Monosodium glutamate with the rate of 2g/1L has the highest diameter of branch, height of the plant and number of leave; however it is no significant difference with the control. The application of Bokashi and MSG does not give any effect towards soil pH. The organic matter content also decrease because of the nutrient uptake of the plant. There were interactions between Bokashi and MSG towards the height of the plant and number of leaf but there was no interaction towards diameter of the branch.

5.2 Recommendation

MSG did not show significant differences with other treatment. So, there is least effect by using MSG. The use of sprinkler irrigation results least effect of MSG that was applied to the plant as foliar application. This is because when MSG was applied, MSG maybe did not have enough time to absorb because of the water that was water on the surface of leaf. As for better absorption, drip irrigation was suggested to give enough water towards the plant.

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APPENDIX A

Figure A.1 Left view of Pak choy that was planted in open field

Figure A.2. Right view of Pak Choy at open field

Figure A.4. Poly bag of Bokashi that was place on bench in greenhouse

Figure A.5.Poly bag of MSG that was place on the bench in green house

Figure A.6. The growth stage of Pak choy that applied with Bokashi after 1 week.

Figure A.7 The growth stage of Pak choy that applied with MSG fertiliser after 1 week