Impacts of Bokashi on Growth and Yield of Common Bean (*Phaseolus vulgaris L.)*

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DECLARATION

I hereby declare that the work contained in this report is the result of the original research except the citations and summaries each of which I have explained the source and this work was not submitted to any universities or institutions for a higher degree.

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ABSTRACT

Most of common bean is capable to be produced in Malaysia but production of common bean in our country is insufficient to meet with local market demand. In conventional farming, farmers typically applied 10,000 kg / ha of compost during preparation of bed. So, this research were trying to decrease the amount of compost used by investigating the best dosage of bokashi application. The objective of this research was to assess the growth performance and yield of common bean when different amounts of bokashi are applied. Randomized Block Design (RBD) with three replicates for each treatment were used in this research. There were six treatments of different amounts of bokashi which is 0kg/ha (as negative control), 2000kg/ha, 4000kg/ha, 6000kg/ha, 8000kg/ha of bokashi and 10000kg/ha of compost as the positive control. There are 9 parameters were taken for analysis such as plant height, number of leaves, number of branches, number of flowers per plant, numbers of flowers per plot, number of pod per plant, number of pod per plot, yield per plant and yield per plot. The results showed that the treatment that has high growth production was treatment 5 that contained 8000kg/ha bokashi and the treatment that produced high number of yield was treatment 2 that contained 2000kg/ha bokashi.

Keywords: bokashi, common bean, morphology, growth, yield

Kesan Bokashi pada Pertumbuhan dan Hasil Kacang Buncis (*Phaseolus vulgaris* L.)

ABSTRAK

Kebanyakan kacang buncis mampu dihasilkan di Malaysia tetapi pengeluaran kacang buncis di negara kita tidak mencukupi untuk memenuhi permintaan pasaran tempatan. Dalam pertanian konvensional, petani biasanya menggunakan kompos 10,000 kg / ha semasa penyediaan batas. Oleh itu, kajian ini cuba mengurangkan jumlah kompos yang digunakan untuk menyiasat kadar terbaik aplikasi bokashi. Objektif penyelidikan ini adalah untuk menilai prestasi pertumbuhan dan hasil kacang buncis apabila jumlah bokashi yang berbeza digunakan. Rekabentuk Blok Rawak (RBD) dengan tiga ulangan bagi setiap rawatan telah digunakan dalam kajian ini. Terdapat enam rawatan bokashi yang berbeza iaitu 0kg/ha (sebagai kontrol negatif), 2000kg/ha, 4000kg/ha, 6000kg/ha, 8000kg/ha bokashi dan 10000kg/ha compost sebagai kontrol positif. Terdapat 9 parameter yang diambil untuk analisis seperti ketinggian tumbuhan, bilangan daun, bilangan cabang, bilangan bunga per tumbuhan, bilangan bunga per plot, bilangan pod per tumbuhan, bilangan pod per plot, hasil per tumbuhan dan hasil setiap plot. Hasil eksperimen untuk kajian ini menunjukkan bahawa rawatan yang mempunyai pengeluaran pertumbuhan yang tinggi adalah rawatan yang mengandungi bokashi 8000kg / ha dan rawatan yang menghasilkan jumlah hasil yang tinggi adalah rawatan yang mengandungi 2000kg / ha bokashi.

Kata kunci: bokashi, kacang buncis, morfologi, pertumbuhan, hasil

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LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviations		Page
ANOVA	Analysis of variance	21
EM	Effective microorganism	11
ha	Hectare	3
Mt	Megatonne (10^9 kg)	3
NPK	Nitrogen, phosphorus, potassium	15

Symbols

g	Gram	14
mg	Milligram	14
ug	Microgram	14

CHAPTER 1

INTRODUCTION

1. Research Background

Most of vegetables is capable to be produced in Malaysia. However the production of vegetables in our country is not enough to meet with local market demand. Moreover, vegetable cost of production in Malaysia is high due to expensive labour and pesticide. Malaysia have to import vegetables from all over the world such as Thailand and China and also because it is cheaper than production cost (Ruban, 2016). Thus, in order to increase the production of vegetables in Malaysia and lower its cost, all farmers should practice the economical and correct cultivation method. The appropriate utilization of soil amendment and chemical fertilizer should be met.

Common bean (*Phaseolus vulgaris* L.) is a legume that has a sweet and crunchy taste. It helps lower blood pressure, maintain sugar metabolism in blood and it also contains enzyme that can help lower body weight naturally (Utusan, 2011). As such,common bean make food and nutrition safer for poor consumers, while reducing the risk of cardiovascular disease and diabetes. (Grain Legumes, 2018). According to Szyndler *et al*(2013), common bean leaves can also be used for trapping bedbugs inside houses. Other than that, immature pods are freshly eaten and can easily be preserved through freezing, canning or dehydration. The versatility in cooking make it an interesting and valuable crop. Common bean are eaten boiled, baked, fried or ground into flour. Dried pods and stems can be turned to straw and discarded pods can be used as fodder (Wortmann *et al*, 2006). According to Castro-Guerrero (2016), common bean also has the economic and environmental benefits of combining with nitrogen - fixing bacteria, thereby reducing the use of synthetic fertilizers that are key to sustainable agriculture.

According to Malaysia Department of Agriculture (2016) farmers in some states in Malaysia grow common bean commercially. The biggest plantation of common bean is in Pahang followed by Sarawak, Sabah, Perak, Malacca and Kelantan. Table 1.1 shows the production of common bean in Malaysia. Total area with cultivated common bean keep increasing until the year 2015.

Based from Table 1.1, it shows that the hectarage of common bean keep increasing from year 2014 to 2015. It starts to decrease in year 2016. The demand for common bean is keep increasing from year 2014 to 2015 (Malaysia Department of Agriculture, 2016)

Table 1.1: Hectarage of common bean by state in Malaysia from 2014 to 2016

State	2014		2015		2016	
	Harvested area (ha)	Production (Mt)	Harvested area (ha)	Production (Mt)	Harvested area (ha)	Production (Mt)
Johor	9.6	143.8	60.78	726.58	4.40	48.82
Kedah	0.1	0.7	3.00	22.10	3.40	51.23
Kelantan	29.4	502.5	35.85	589.89	9.72	202.37
Malacca	21.6	181.0	41.85	305.66	19.40	228.27
Negeri Sembilan	6.0	96.4	6.30	102.21	5.60	74.23
Pahang	843.3	12029.5	831.90	11850.99	674.10	9235.35
Perak	25.9	326.6	34.99	432.79	18.51	256.76
Perlis	0.0	0.0	0.0	0.0	0.0	0.0
Pulau Pinang	1.4	12.0	2.18	18.75	0.98	9.49
Selangor	1.0	7.8	1.00	11.00	0.50	3.50
Terengganu	0.40	1.48	0	0	0	0
Peninsular Malaysia	938.6	13301.6	1017.9	14060.0	736.6	10110.0
Sabah	38.6	329.7	34.00	261.3	38.40	292.60
Sarawak	109.6	1021.0	109.52	1020.40	120.59	1110.80
W. P. Labuan	0.60	0.50	0.0	0.0	0.0	0.0
Total	1087.4	14652.8	1161.4	15341.7	895.6	11513.4

Source: Malaysia Department of Agriculture (2016).

Farmers all over the world typically use conventional method as a way for them to plant their crop. Conventional method is by depending on using the chemicals substances in fertilizers and pesticides. Using excessive chemicals in farming method can generate negative effect to the environment. Soil fertility was reduced when farmers only depend on the chemicals fertilizer to raise their production. Moreover, huge amounts of chemicals use can also cause water pollutants (Savci, 2012). Singh *et al* (2006) states that the continued use of chemicals in agriculture has shown its potential to percolate and reach groundwater. Once in groundwater, pesticides and their degradation products can persist for years, depending on the chemical structure of the compounds and environmental conditions (Bicki, 1989).

According to U.S. Environmental Protection Agency (2017), many chemical pesticides can have harmful effects on humans, either as acute or chronic toxicity. Acute exposure to pesticides can lead to death or serious diseases (World Health Organization, 1990). The cumulative health effects of human exposure to various agrochemicals can be a factor in a range of chronic conditions and diseases such as cancer, reproductive, endocrine, immunological, congenital and developmental disorders. (Jurewicz & Hanke, 2008). Hence, this research was done to study the impact of different dosages of bokashi application on the growth and yield of common bean. It is predicted that the results from this research can decrease the amount of compost application and the best dosage of bokashi for common bean can be found.

1.1 Problem Statement

To assure continuous supply of common bean in Malaysia, correct and economical farming practices should be used. Appropriate amount of bokashi should be applied. Purpose of compost as soil amendment is important in producing higher yield. In conventional farming, farmers typically applied 10,000 kg / ha of compost during preparation of bed (Network, 2010). This amount is quite high. So, this research is trying to decrease the amount of compost used by investigating the best dosage of bokashi application.

1.2 Hypothesis

For null hypothesis, is the different amounts of bokashi treatment will not have significant impact on growth and yield of common bean. Then, for alternate hypothesis, there is at least one bokashi treatment that will have significant impact on the growth and yield of common bean.

Based from this research, the following hypothesis will be tested:

H0= There is no impact on growth and yield of common bean after applying bokashi.

H1= There is impact on growth and yield of common bean after applying bokashi.

1.3 Objectives

The objective of this research was to assess the growth performance and yield of common bean when different amounts of bokashi are applied.

1.4 Research question

1. Does varied amount of bokashi influence the growth and yield of common bean?

1.5 Scope of Study

This research was focused on the impacts of different dosage of bokashi on growth and yield of common bean and finding the best dosage of bokashi for common bean. There were 6 treatments with different dosage of bokashi.

1.6 Significance of Study

This research is to learn the best dosage of bokashi on common bean. With the sufficient rate of bokashi, it may produce greater yield. Bokashi process is distinct from traditional composting. Bokashi have two usefulness that are one of them as fertilization and another is microorganism propagated through fermentation process that improve activities of plants particularly in roots. Use of the bokashi can also increase the growth of a healthy crop applied by farmers

CHAPTER 2

LITERATURE REVIEW

2.1 Botany

2.1.1 Taxonomy

Common bean (*Phaseolus vulgaris*) is a type of plant belonging in the family Fabaceae. It is called 'kacang buncis' and it is grown as fruit type vegetable for export and domestic purposes (Anem, 2015). According to Groce (2018) common bean is in the same family with peanuts and soybeans. Common bean is originated from Mesoamerica which are Mexico and Central America. It is now cultivated in all over the world especially in China as its largest producers (Bitocchi *et al*, 2012). There are many common names of common bean. Some of them are called green bean, French bean, pop bean and string bean (Gentry, 1969).

Below is the taxonomy of common bean:

Kingdom	: Plantae - Plants
Subkingdom	: Tracheobionta – Vascular plants
Superdivision	: Spermatophyta – Seed plants
Division	: Magnoliophyta – Flowering plants
Class	: Magnoliopsida - Dicotyledons
Subclass	: Rosidae
Order	: Fabales
Family	: Fabaceae / Leguminosae
Genus	: *Phaseolus* L.
Species	: *Phaseolus vulgaris* L.

Source: United States Department of Agriculture (2018)

2.1.2 Morphology

According to Koning (1994) the leaves of the common bean shape is wideoval and are broad at the blade and attached to the stem by means of a stalk- like petiole. Its leaves can be simple with a single blade per petiole or compound, which usually has three blades per petiole. Two simple leaves or a compound leaf can be attached to a place on the stem called a node. The veins of each blade of leaf are organized into a complex network. Where the stem and leaf join, there is a swollen area of the pulvinus, which is responsible for the movement of the leaves. At night, the common bean folds down to the ground, while at dawn, the leaves unfold and are lifted to the sun. (Tomlinson, 1970).

Malaysia Department of Agriculture Penang (2018) states that common bean has a climbing habit which makes it grows upwards by wrapping around pole. The stem height can reach up to 2 m. Its root is taproot and from it comes out lateral roots where they expand wider. Its flowers are coloured white, pink or yellow. Common bean is a self-pollinated crop. Its pods colour ranges from light green to dark green and measured at 15-20 cm each pod (Anem, 2015).

The stem of the bean is quite long, soft and the internodes between the nodes are quite obvious. The lower part of the stem is below the cotyledons and is called hypocotyl. The stem ends in the apical bud at the top of the plant. Lateral buds are found in each leaf's axles just above the node (Koning, 1994). The stem tips of the pole bean grow very quickly and "whip around" several cycles a day. When the stem touches an object, changes in plant hormone production cause the stem to twist and grow upwards. This twining habit is called circumnutation and is common in vines (Tomlinson, 1970).

2.2 Agronomy

Common bean is classified as herbaceous annual plant and can be cultivated worldwide. Common bean can grow up to 2-3 m (Anem, 2015). There are many advantages of planting common bean. First, common bean only takes about 6 – 7 weeks after sowing that they can be harvested. Its duration for harvesting is 5 weeks. Its harvesting frequency is every 2-3 days. Other than that, common bean can easily grow as an uncovered crop or even in protected cultivation. This crop is grown by using seeds. The seeds can be directly sown to the field. It gets higher yield after application of organic or chemical fertilizer. According to Malaysia Department of Agriculture Penang (2018) common bean require 25 – 35 ^{O}C temperature and 168 mm/month rainfall which are suitable to grown in equatorial climate countries such as Malaysia. Type of soil suitable for common bean are peat soil, BRIS soil, mineral soil and ex-mining soil and at 5.5 - 6.8 pH level of the soil.

According to CABI Crop Protection Compendium (2017) among the pests of common bean in Malaysia are Aphids (*Aphis craccivora*) which will suckle the leafy liquid which will cause the leaves to become curly and can be controlled by the pesticide of profenos, diaznon or Malathion. Another pest is the stem fly (*Melannogromyza phaseoli*) attacking the stage of seedlings that can cause death of the seeds. This pest can be controlled by deltamethrin, diaznon, dimethoate or trochlorfon (CABI Crop Protection Compendium, 2017). Bean pod borer (*Marucca festulis*) is a worm attacking leaves and pods causing stunts and defects that can be controlled by systemic type of toxins such as poison indoxacarb, alphacypermethrin, lufenuron, deltamethrin or acetamidprid type poison. Reputation of gram blue (*Euchrysops cnejus*) eating beans that cause perforation in the fruit is controlled by cypermathrin poison. The correct dosage should be applied according to the label on the pesticide bottle (Anem, 2015).

Diseases of common bean such as black spot disease (*Colletotrichum lindemuthianum*) can be controlled by treating seeds with captan pesticide, making sure drainage system is good and spray maneb or mancozeb pesticide. Bean rust (*Uromyces appendiculatus*) can be treated by spraying mancozeb or copper oxychloride. Lastly, root rot (*Rhizoctonia solani*) is controlled by removing and burn diseased tree and pouring captan pesticide on nearby trees (Malaysia Department of Agriculture Penang, 2018).

2.3 Bokashi

According to Vanderlinden (2017), bokashi in the Japanese language means fermented organic matter and it is the same to compost used in farming process. Composting is the biological breakdown of the organic material into a hummus-like compost. The process takes place naturally, but can be accelerated and improved by monitoring environmental factors. Moreover, a properly controlled composting environment can ensure that the high temperatures needed to kill weeds, plant tissue and pathogenic organisms are produced (Smith & Friend, 2018). Traditional composting actually releases a lot of greenhouse gases to the atmosphere. In contrast, the anaerobic bokashi process releases little (if any) harmful greenhouse gas (Casley, 2015).

According to Amano (1999), Japan has been using bokashi since 1935. Effective microorganisms (EM) addition are required in producing bokashi. There are many different formulations of bokashi production. Majority of bokashi in the market are added with effective microorganisms (EM). According to Fontenelle *et al* (2015) effective microorganisms (EM) is a compound microbial inoculum that is established by Prof Teruo Higa from RyuKyus University in Japan.

Effective microorganisms (EM) has multiple purposes to improve production in numerous crops because it is rich in photosynthetic bacteria, yeast, bacteria, actinomycetes, and other organisms that occur naturally in the environment (Fontenelle *et al*., 2015). The use of EM Bokashi on the surface soil is responsible for biological pasteurization. However, the subsurface area is oxygenated. The fermentation of the soil surface damages and suppresses the roots of germinating weeds. (Amano, 1999). Presence of EM is to suppress pathogens like *E.Coli* and also to improve soil suppression (Al-Fraih, 2015).

United States Sustainable Agriculture Research and Education (SARE) observed that bokashi has low nitrate content and high in ammonium and its application on soil can improve plant yield and growth. This can be seen that bokashi has capability to make soil more fertile. Based from their economic analysis, researchers discover that bokashi can work in minor scale operations (Education, 2016).

Jaramillo-López *et al* (2015) discovered that bokashi can decrease agricultural input cost because bokashi price is lower than chemical fertilizers. Price of bokashi is cheaper and more reasonable compared to chemical fertilizers. This will increase small scale farmer production. For some farmers that have knowledge on producing bokashi, they can produce it on their own. Bokashi contain organic waste and manure that are fermented using EM (Jaramillo-López *et al*., 2015).

According to Fontenelle *et al* (2015), bokashi can speed up growth of plants height and enhance seedling survival. Bokashi application can help transplanted seedlings to survive from shock and frost conditions in the field. Fontenelle *et al* (2015) also believe that application of bokashi can enhance soil fertility because of the better growth and progress after seedlings have been transplanted to the field. According to Brady & Weil (2002), biofertilizer such as bokashi can increase soil fertility, improve microbial activity, physic-chemical properties and soil characteristic. Moreover, Boechat, *et al* (2013) discovered that bokashi amplified nitrogen concentration on soil and improved soil chemical properties. It also improved and quickened the degradation of organic matter, causing net nitrogen in rapidly available quantities and also soil fertility which gives a faster quantity of available nutrients for crops. Other than that, Sahain *et al*. (2007) detected that bokashi improved the value of soil elements compared to untreated soil. Another study by Suthamathy & Seran (2013) said that bokashi can also enhance soil fertility on sandy regosol. Christel (2017) said that bokashi treatments significantly enhanced soil fertility characteristics of loamy sand soil. It also provided an extra sustained quantity of inorganic nitrogen to plants than vermicompost, and an additional immediately amount of inorganic nitrogen than thermophilic compost. Christel (2017) also states that in bokashi applications, the profitability was somewhat higher compared to commonly used compost and vermicompost, and the microbial community in bokashi applications had a carbon-substrate utilization pattern distinctive of all other treatments. Bokashi may be an appropriate complement or alternative to vermicompost and compost in soil fertility management in organic vegetable cultivation systems (Christel, 2017).

2.4 Nutrition Composition

According to Table 2.1, common bean is rich with carbohydrates, protein and fibre. It is also contain a good source of calcium, vitamin C and potassium. Although significantly less than cereals, common bean are a cheap source of vegetable protein, calories and micronutrients. (Lioi & Piergiovanni, 2013). In addition to caloric intake, it is widely appreciated in developing countries for its affordability compared to animal protein and the long storage life of common bean. (Castro-Guerrero *et al*, 2016).

Table 2.1: Nutrition composition in common bean

Content	Amount/100 g
Protein	2.3 g
Carbohydrates	6.2 g
Fat	0.2 g
Fibre	1.5 g
Calcium	54.0 mg
Iron	1.8 mg
Phosphorus	6.0 mg
Potassium	75.0 mg
Sodium	34.0 mg
Beta Carotene	1036.0 ug
Vitamin B1	0.1 mg
Vitamin B2	0.2 mg
Vitamin C	15.8 mg
Niacin	0.1 mg

Source: Malaysia Department of Agriculture Penang (2018)

CHAPTER 3

MATERIALS AND METHOD

3.1 Site, time and plant materials

This experiment was done from July 2018 - December 2018 at Agropark UMK Jeli Campus in Kelantan, Malaysia. The plant materials and equipment that was used in this experiment are 20 pack of seed of common bean cultivar 'MKB 1' from MARDI, compost (free peat holland), bokashi, silver shine plastic, plastic rope, bamboo, hoe, measuring tape, hand trowel, balance, watering hose, chemical fertilizer NPK 15:15:15 and planting tray.

3.2 Experimental layout

There were 3 replications within 18 plots. Each replication contains 6 plots that are different treatments of bokashi dose. The size of one plot has been fixed to 1 m x 3 m as represented in Figure 3.2. There were 10 common bean plants in each plot as shown in Figure 3.1. Total planting area for this research is 20.1 m x 5 m.

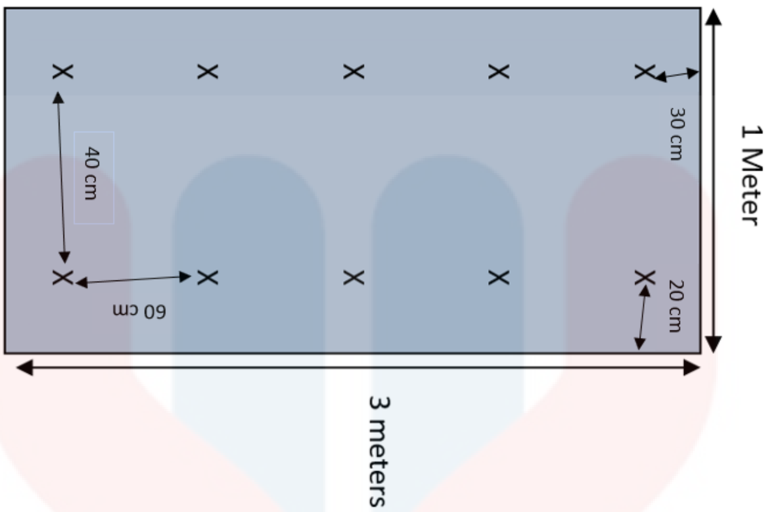

Figure 3.1: Planting area for common bean

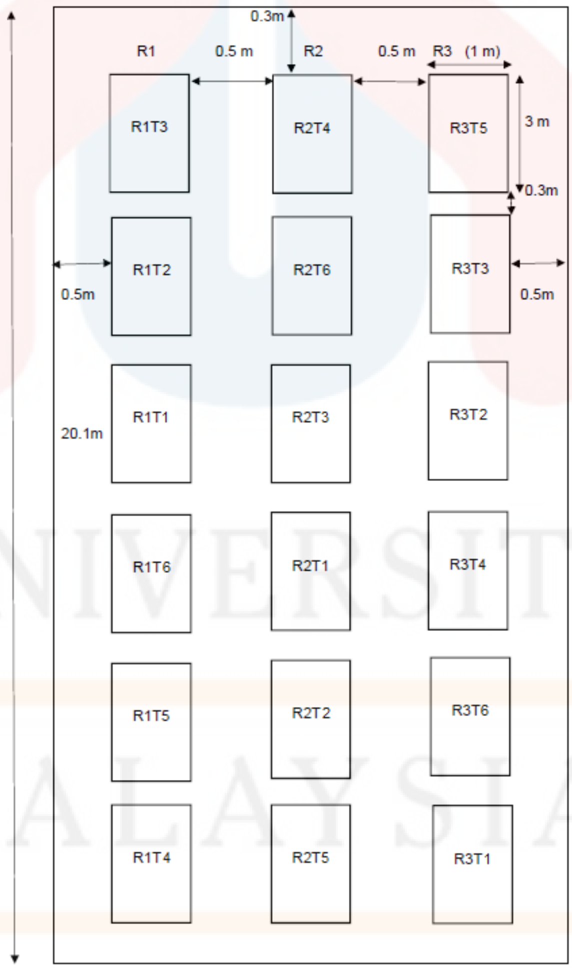

Figure 3.2: Experimental Layout

3.3 Methods

3.3.1 Land preparations

First, the land was cleared by ploughing following the area. All unwanted things such as stones, gravel, weeds and so forth were removed. Then, the soils were loose to make the planting process become easier. After that was the levelling process. The purpose of levelling the soil is to help in irrigation process with efficiency of water use besides helping in draining excess water during heavy rain or immediately after irrigation. After that, same amount of NPK fertilizer which is 210 gram for every bed were added to the soil and mixed well. Common bean plant required 105kg/ha of nitrogen, 105kg/ha phosphorus and 105kg/ha potassium. So, 700kg/ha of NPK 15:15:15 were used. Then, the soil was covered by silver shine to prevent from germination of weeds.

3.3.2 Seedlings preparations

Two seedling trays were needed to prepare 180 seeds of common bean. Then, two rows of seedling were planted in each plot which is one row has 5 seedlings. For 1 plot of common bean plants, there were 10 seedlings and total of all seedlings that was used are 180 seedlings from 18 plots.

3.3.3 Transplanting

The transplanting of seedlings is ready after 7 days. The planting space between rows is 60 cm while within row is 40 cm. As the plots were covered by silver shine, holes are needed before transplanting process. So, for the holes, a can was used to makes holes. Any plants that die after transplanting were transplanted again.

3.3.4 Watering

For getting maximum yield of common bean, the common bean crops must not have excess water because it cannot withstand heavy moisture content. Too much water applied on the common bean crops will result in the decreasing of vegetative growth and shedding of the flowers. Hence, watering process only needs to be applied when it is necessary. However, irrigation process is very important for the common bean's pod and flower development.

3.3.5 Harvesting

Harvesting process was done after 35-42 days after transplanting. Common bean crops can be harvested for about 10-11 times as it can survive for three months. Harvesting process was done every 2-3 days.

3.4 Experimental Design and random sampling

Randomized block design was used in this study that consisted of one factor (bokashi) with 6 levels. Every treatment was repeated three times among which four plants randomly chosen as samples for each plot. The treatments were:

T1: 0 kg of bokashi per hectare (negative control) (0g per plot)

T2: 2000 kg of bokashi per hectare (0.6 kg of bokashi per plot)

T3: 4000 kg of bokashi per hectare (1.2 kg of bokashi per plot)

T4: 6000 kg of bokashi per hectare (1.8 kg of bokashi per plot)

T5: 8000 kg of bokashi per hectare (2.4 kg of bokashi per plot)

T6: 10000 kg of compost (free peat holland) per hectare (positive control) (3.0 kg of compost per plot)

3.5 Data collection

Data of the plant for this research were taken until the harvesting process. In this research, dependent variables that were observed were:

i. Plant height

Plant height were measured and recorded every week throughout the first 8 weeks until it reach their maximum height. The plant height was measured from the base of the plant to the tip of the shoot.

ii. Number of leaves per plant

Numbers of leaves were counted and recorded one by one starting from the first week until the eighth weeks.

iii. Number of branches per plant

Numbers of branches were counted and recorded one by one starting from the first week until the eighth weeks.

iv. Number of flowers per plant

For the number of flowers per plant, data were counted and recorded for each plant from week 5 - 8.

v. Number of flowers per plot

For numbers of flowers per plot, data were counted and recorded for each plot starting from week 5-8.

vi. Number of pods per plant

For number of pods per plant, data were counted and recorded for each plant.

vii. Number of pods per plot

For number of pods per plot, data were counted and recorded for each plant.

viii. Yield per plant

For yield per plant, the data that were collected and recorded is average yield for each plant.

ix. Yield per plot

For yield per plot, the data that were collected and recorded is total yield for each plot.

3.6 Data Analysis

The data on different dosages of treatment was collected and analysed. For the data analysis, ANOVA and Post Hoc Analysis by using Duncan Multiple Range Test were used to analysed and differentiate the results from the treatment using software SPSS and Microsoft Excel

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Plant height

Figure 4.1 presents the height of common bean with different treatment of bokashi. During early phase after transplanting, all treatments did not show height difference. However, the height of common bean drastically increased on day 21 to day 56. Treatment 5 represented 8000kg/ha of bokashi shows the highest average height. For other treatments, average height are fairly close. Data on Table 4.1 showed that (P≤0.05). Thus there is significant different between treatments.

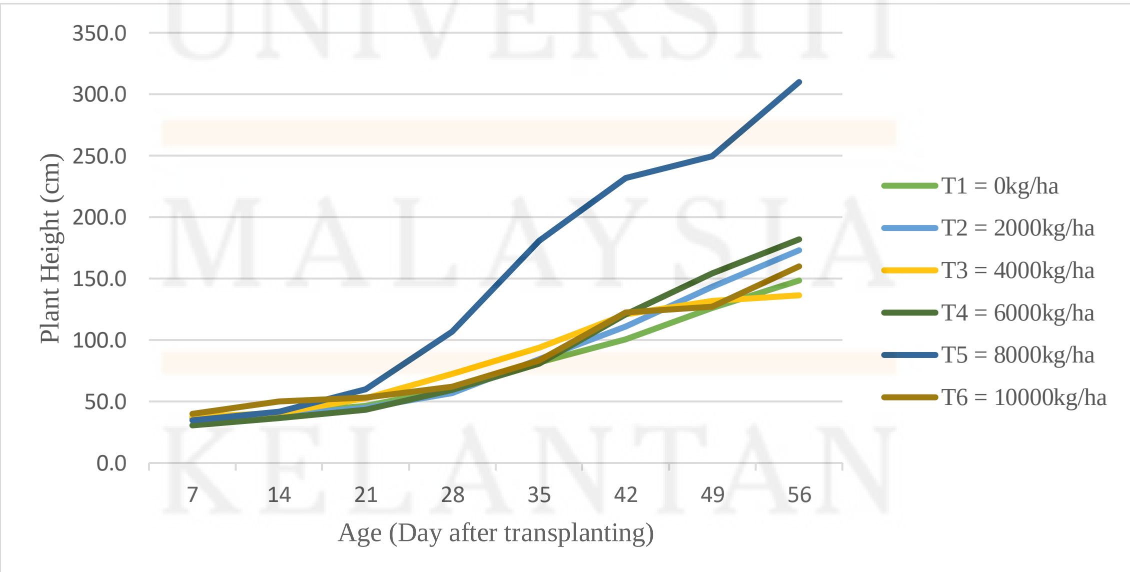

Figure 4.1: Average plant height (cm)

Table 4.1: Effects of bokashi on plant height

Treatment	Plant Height (cm)		
	21 DAT	35 DAT	49 DAT
T1 = 0kg bokashi /ha	46.7[a]	82.1[b]	126.2[b]
T2 = 2000kg bokashi/ha	44.7[a]	84.6[b]	143.2[ab]
T3 = 4000kg bokashi/ha	52.9[a]	93.6[b]	132.1[b]
T4 = 6000kg bokashi/ha	43.3[a]	80.8[b]	154.4[ab]
T5 = 8000kg bokashi/ha	60.0[a]	180.7[a]	249.6[a]
T6 = 10000kg compost/ha	53.2[a]	83.5[b]	127.0[b]

Values followed by same letter in same column means there is no significant different according to DMRT for alpha 0.05

From the Table 4.1, the treatments shows significant difference at 35 DAT (Day After Transplant) and 49 DAT. At 21 DAT, there is no significant difference between treatments. However at 35 DAT it starts to show that there is significant difference between treatments. The highest plant height produced by Treatment 5 which significantly different than other treatments at 35 DAT. Overall, there is significant difference between Treatment 5 with Treatment 1 and Treatment 6. Normal height of common bean is 2 m (Duke, 1998). Through this research, only Treatment 5 achieved more than 2 m. Other treatments were recorded below the normal height. Overall, treatment with bokashi application almost achieved the normal height compare to compost application and no application of bokashi.

We can see clearly that application of bokashi affects the height of plants when dosage of bokashi increases, the height also increase. This can be seen among bokashi treatments. Treatment 3 produced plant with the lowest height. While, when compared to control, the heights are more than plant height from control treatment. Thus, it can be simply that, if we keep increase the dosage of bokashi, it resulted good growth and development for plant. According to Soeparjono (2016), it is stated that bokashi with the compositions of 60 percent: 20 percent: coconut peat 20 percent had a very clear effect on plant height, number of leaves, yield, biomass and other parameters. Besides, compost like bokashi have a very important effect that shows better response on the growth of plant. Study by Sutanto (2002), stated that generally organic fertilizer contains very small amounts of macro nutrients N, P, K. But, bokashi contain enough amounts of micro nutrients that is absolutely necessary in plant growth. Thus, it shows bokashi allows fulfil the needs of macro and micro nutrients for growth of plants.

4.2 Number of leaves

Figure 4.2 provides the number of leaves during 8 weeks after transplanting. During week 1, average number of leaves are same for all treatments. All treatments started producing more number of leaves starting from week 2 to week 8. Highest number of leaves was achieved by Treatment 5. This shows that common bean treated with bokashi can produce more leaves compared with no bokashi application and compost application.

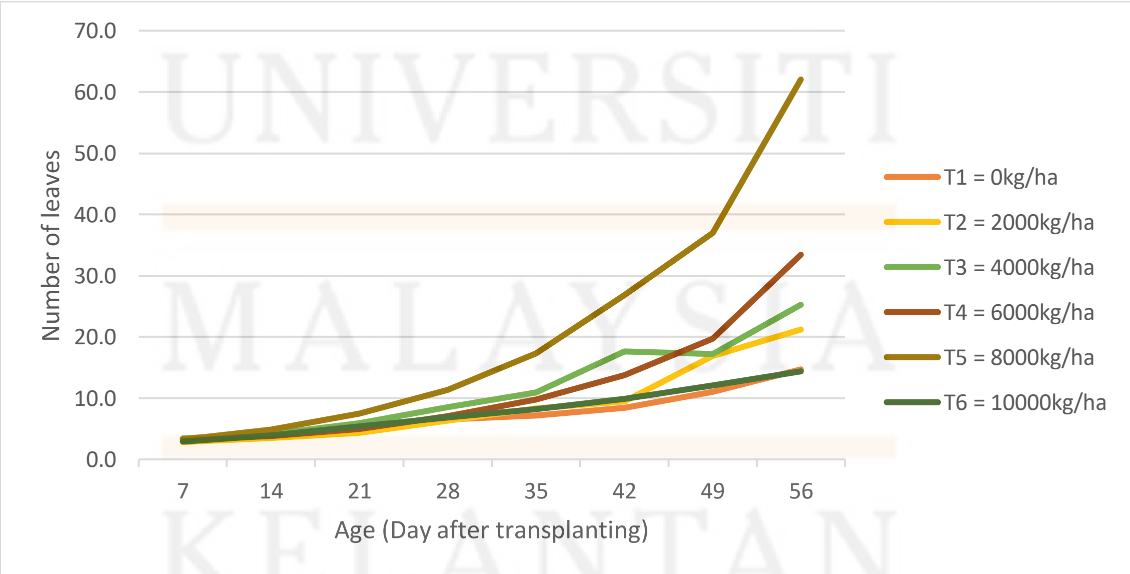

Figure 4.2: Number of leaves

The effect of different treatment on the number of leaves at 21 DAT, 35 DAT and 56 DAT intervals are shown in Table 4.2 that demonstrate number of leaves are higher in treatments with bokashi while lower in treatment without bokashi and treatment with compost.

Table 4.2: Effects of bokashi on number of leaves

Treatment	Leaves		
	21 DAT	35 DAT	56 DAT
T1 = 0kg bokashi /ha	5.1[bc]	7.2[b]	14.7[b]
T2 = 2000kg bokashi/ha	4.3[c]	8.3[b]	21.3[ab]
T3 = 4000kg bokashi/ha	5.9[b]	10.9[b]	25.3[ab]
T4 = 6000kg bokashi/ha	5.0[bc]	9.8[b]	33.4[ab]
T5 = 8000kg bokashi/ha	7.5[a]	17.4[a]	62.0[a]
T6 = 10000kg compost/ha	5.4[bc]	8.3[b]	14.4[b]

Values followed by same letter in same column means there is no significant different according to DMRT for alpha 0.05

The data given in Table 4.2 indicates significant differences among treatments for number of leaves at 21 DAT, 35 DAT and 56 DAT. The highest number of leaves produced by Treatment 5 which is significantly different from other treatments is at 35 DAT. Even though the number of leaves of Treatment 2 and Treatment 1 are far apart, they are not significantly difference. This is because the variance are big. Other than that, number of leaves per plant is another important growth parameter in this study. Thus, the more plant height, the greater will be the number of leaves. This indicates when plant height increases number of leaves also more.

4.3 Number of branches

Figure 4.3 shows the number of branches after 7 to 56 day after transplanting. All treatments except Treatment 5 started to produce branches from week 2 to week 6. Highest number of branches had been achieved by Treatment 5. Treatment 5 produced 43% number of branches more than no bokashi application and 3 times number of branches more than compost application at 35 DAT. This shows that common bean treated with bokashi can produce more branches compared with 0kg/ha of bokashi and 10000kg/ha of compost. It is observed that from data in Table 4.3, there are no significant effect among all treatment. When compare treatments of bokashi with untreated bokashi and compost application, there are no significant different in number of branches.

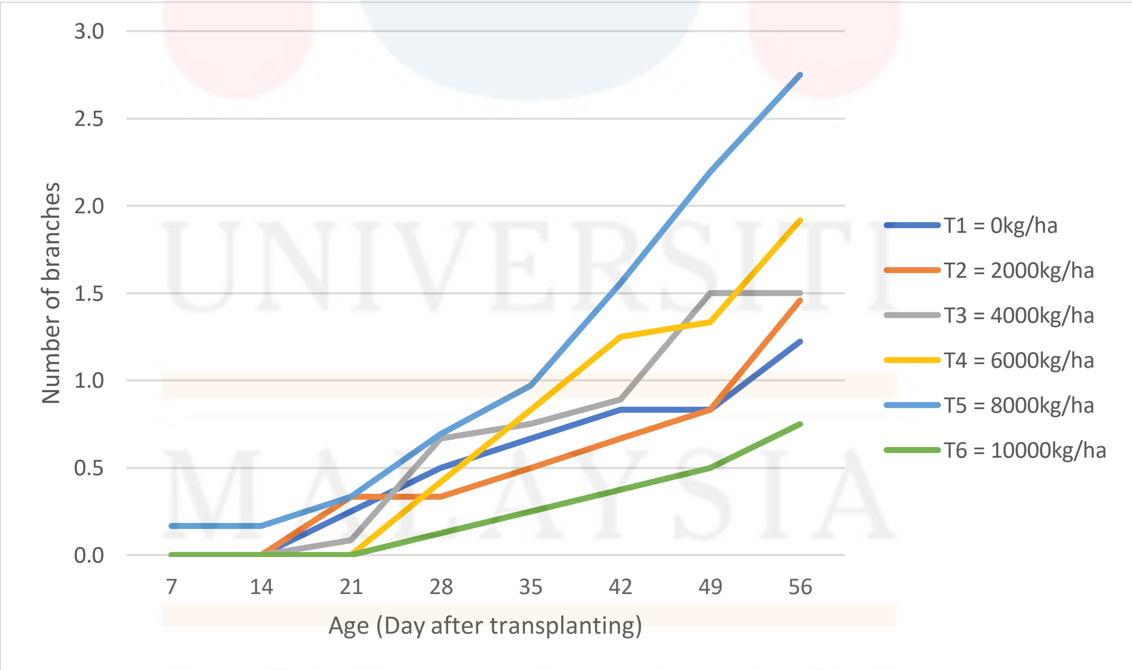

Figure 4.3: Number of branches

Table 4.3: Effects of bokashi on number of branches

Treatment	Branches		
	21 DAT	35 DAT	56 DAT
T1 = 0kg bokashi /ha	0.3^{a}	0.7^{a}	1.3^{a}
T2 = 2000kg bokashi/ha	0.3^{a}	0.5^{a}	1.5^{a}
T3 = 4000kg bokashi/ha	0.1^{a}	0.8^{a}	1.5^{a}
T4 = 6000kg bokashi/ha	0.0^{a}	0.9^{a}	2.0^{a}
T5 = 8000kg bokashi/ha	0.4^{a}	1.0^{a}	2.8^{a}
T6 = 10000kg compost/ha	0.0^{a}	0.3^{a}	0.8^{a}

Values followed by same letter in same column means there is no significant different according to DMRT for alpha 0.05

4.4 Number of flowers per plant and number of flowers per plot

Table 4.4 shows the average number of flower per plant and average number of flower per plot. Treatment 5 had the highest average number of flower per plant and highest average number of flower per plot. From table 4.4, it shows that treatment 5 have significant different on the number of flower per plant and number of flower per plot of common bean compared with untreated bokashi and compost application.

Table 4.4 Effects of bokashi on number of flowers

Treatment	Number of flower per plant	Number of flower per plot
T1 = 0kg/ha	6.0^{b}	60.0^{b}
T2 = 2000kg/ha	10.6^{ab}	106.0^{ab}
T3 = 4000kg/ha	14.1^{ab}	141.1^{ab}
T4 = 6000kg/ha	19.4^{ab}	194.1^{ab}
T5 = 8000kg/ha	21.3^{a}	212.8^{a}
T6 = 10000kg/ha	10.1^{ab}	101.3^{ab}

Values followed by same letter in same column means there is no significant different according to DMRT for alpha 0.05

From Treatment 1 to Treatment 5, the average number of flower per plot and number of flower per plant gradually increase. Treatment 1 had the lowest average number of flower per plot and lowest average number of flower per plant. The best treatment is Treatment 5. Treatment 5 produced 3 times number of flowers more than no bokashi application and double number of flowers more than compost application.

4.5 Number of pod per plant and number of pod per plot

Table 4.5 shows the average number of pods per plant. Treatment 4 and Treatment 5 have no significant effect on the average number of pod per plant. Treatment 2 had the highest average number of pod per plant. Treatment 1 had the lowest average number of pod per plant. Treatment 2 is the best treatment and that treatments of bokashi have significant effect on the number of pod per plant of common bean.

Table 4.5: Effects of bokashi on number of pod

Treatment	Number of pod per plant	Number of pod per plot
T1 = 0kg/ha	3.4^{d}	34.0^{d}
T2 = 2000kg/ha	30.1^{a}	301.0^{a}
T3 = 4000kg/ha	14.2^{c}	141.7^{c}
T4 = 6000kg/ha	21.6^{b}	216.3^{b}
T5 = 8000kg/ha	22.3^{b}	223.0^{b}
T6 = 10000kg/ha	10.0^{c}	100.0^{c}

Values followed by same letter in same column means there is no significant different according to DMRT for alpha 0.05

Treatment 2 had the highest average number of pod per plot. Treatment 1 had the lowest average number of pod per plot. The average number of pod per plant gradually increase from Treatment 3 to Treatment 5. Treatment 2 produced 9 times number of pod more than no bokashi application and 3 times number of pod more than compost application. From the Duncan test, it shows that Treatment 2 is the best treatment. It also showed that bokashi application have significant effect on the number of pod per plot of common bean compared to no bokashi application and compost application.

4.6 Yield per plant and yield per plot

Table 4.6 shows the yield of common bean per plant. Treatments 2 produced the highest yield per plant. Among bokashi treatment, the yield obtained was not significantly difference for Treatment 4 and Treatment 5. Treatment 2 produces more yield than Treatment 1 and Treatment 6 that indicates the significant difference production of common bean between all treatments. Thus, this shows that different amounts of bokashi have significant difference between all treatments. This means different dosage of bokashi does significantly affect the yield of common bean. Therefore, any application of bokashi can be apply to achieve better yield instead reducing the cost. Thus, Treatment 2 should be applied since it is the best treatment while also have lower dosage of bokashi compared to other bokashi dosage but still have the most significant effect on yield of common bean.

Table 4.6: Effects of bokashi on yield of common bean

Treatment	Yield per plant (g)	Yield per plot (g)
T1 = 0kg/ha	14.4[e]	144.0[e]
T2 = 2000kg/ha	89.9[a]	898.5[a]
T3 = 4000kg/ha	47.7[c]	476.7[c]
T4 = 6000kg/ha	66.5[b]	664.7[b]
T5 = 8000kg/ha	71.6[b]	716.0[b]
T6 = 10000kg/ha	34.7[d]	346.5[d]

Values followed by same letter in same column means there is no significant different according to DMRT for alpha 0.05

Table 4.6 compares the total yield on all treatments. Yields under bokashi treatment are higher than control. The highest yield per plot was obtained by Treatment 2 (898.5 g). Among bokashi treatment, the yield per plot obtained were not significantly different between Treatment 4 and Treatment 5. Treatment 2 produces more yield than Treatment 1 and Treatment 6 that indicates significant difference production of common bean between all treatments. Treatment 2 produced 6 times more yield than no bokashi application and 2 times more yield than compost application. Thus, this shows that different amounts of bokashi on treatment does pose significant effect. This means treatment of bokashi does have significant effect on the yield of common bean. Therefore, any application of bokashi can be apply to achieve better yield while also reducing the cost. Thus, Treatment 2 should be applied since it is the best treatment while also have lower dosage of bokashi compared to other bokashi dosage but still have the most significant effect on yield of common bean. Study by Dou *et al* (2012) stated that application of bokashi increased yield of crop.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

To conclude, bokashi does have effects to the growth and yield of common bean crops. The higher amount of bokashi will results in better growth for common bean crops. Based on this research, T_2 with the lowest amount of bokashi applied are proven to give highest amount of yield. Treatment 2 can produced at least 6 times more yield than no bokashi application and at least 2 times more yield than compost application. Since, bokashi can increase the soil fertility and nutrient availability for crops, thus it can help in increase agriculture production especially in common bean and indirectly reduced the number of abandoned land and amount of imported agricultural products in Malaysia.

5.2 Recommendation

Among recommendations that can be done for future works are vary the types of crops that will be tested for bokashi treatment and the number of imported agricultural products must be reduces by enhancing the local production of agricultural products. Lastly farmers or agricultural manager should start to use bokashi as the benefit of this organic fertilizer is very good and government should subsidize bokashi for farmers so that farmers can use abandoned land for farming thus reducing the number of abandoned land in Malaysia.

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APPENDIX

Table:

Table 6.1: Plant height (cm)

Treatment	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8
T1R1	29.0	30.4	33.6	46.3	62.3	79.0	140.3	189.0
T1R2	40.3	50.4	62.4	86.9	126.0	152.3	158.9	172.4
T1R3	38.8	40.8	44.0	49.0	58.0	71.1	79.3	84.0
T2R1	34.1	34.6	39.3	41.5	47.3	55.4	60.1	66.5
T2R2	40.1	43.8	54.0	79.0	134.0	188.5	-	-
T2R3	35.5	39.4	40.9	49.8	72.4	89.5	226.2	279.7
T3R1	35.8	40.1	60.0	71.9	90.9	135.8	160.1	182.8
T3R2	38.9	41.9	51.0	89.3	121.3	118.0	97.3	57.0
T3R3	37.6	39.9	47.6	56.0	68.6	108.6	138.8	169.5
T4R1	33.0	34.5	41.6	67.3	105.1	167.1	193.3	217.3
T4R2	31.0	45.9	53.6	67.3	76.1	97.9	132.1	143.6
T4R3	27.9	29.3	34.8	44.5	61.3	97.1	137.7	185.0
T5R1	47.0	55.3	82.0	122.4	228.9	286.0	323.5	362.8
T5R2	25.8	28.3	41.6	97.0	158.8	205.8	236.7	366.0
T5R3	31.5	41.6	56.3	101.9	154.4	203.5	188.7	201.0
T6R1	38.6	59.0	67.0	77.0	95.0	126.7	128.0	131.0
T6R2	32.9	34.5	39.3	46.8	71.9	118.8	125.9	188.9
T6R3	48.5	56.5	-	-	-	-	-	-

Table 6.2: Number of leaves

Treatment	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8
T1R1	4	5	6	8	9	11	16	16
T1R2	3	4	5	7	7	8	10	12
T1R3	4	5	5	6	6	7	8	16
T2R1	3	3	4	4	5	6	8	8
T2R2	3	4	5	10	12	13	-	-
T2R3	3	3	5	5	8	9	26	35
T3R1	4	4	6	8	11	18	26	34
T3R2	3	4	7	11	13	24	12	25
T3R3	4	5	6	7	9	12	14	17
T4R1	4	4	5	9	11	14	16	19
T4R2	3	4	4	6	9	11	16	24
T4R3	3	4	6	7	10	17	28	58
T5R1	4	5	9	13	19	27	36	52
T5R2	3	5	7	11	20	36	51	106
T5R3	3	5	7	11	13	19	24	28
T6R1	3	4	6	8	9	10	10	11
T6R2	3	3	5	6	8	10	14	18
T6R3	3	5	-	-	-	-	-	-

Table 6.3: Number of branches

Treatment	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8
T1R1	0	0	1	1	1	1	1	2
T1R2	0	0	0	0	0	0	0	1

T1R3	0	0	0	1	1	1	1	1
T2R1	0	0	0	0	0	1	1	1
T2R2	0	0	1	1	1	1	-	-
T2R3	0	0	0	0	0	1	1	2
T3R1	0	0	0	0	0	1	2	3
T3R2	0	0	0	1	1	1	1	0
T3R3	0	0	0	1	1	1	1	2
T4R1	0	0	0	0	1	1	1	1
T4R2	0	0	0	0	1	1	1	2
T4R3	0	0	0	1	1	2	2	2
T5R1	0	0	0	1	2	3	3	3
T5R2	0	0	0	0	1	2	3	4
T5R3	1	1	1	1	1	1	1	1
T6R1	0	0	0	0	0	0	0	0
T6R2	0	0	0	0	1	1	1	2
T6R3	0	0	-	-	-	-	-	-

Table 6.4: Average flower per plant

Treatment	Number of flower
T1R1	10
T1R2	4
T1R3	4
T2R1	7
T2R2	-
T2R3	14
T3R1	19
T3R2	7
T3R3	17
T4R1	12
T4R2	26
T4R3	20
T5R1	18
T5R2	14
T5R3	32
T6R1	13
T6R2	7
T6R3	-

Table 6.5: Average flower per plot

Treatment	Number of flower
T1R1	100
T1R2	40
T1R3	40
T2R1	68
T2R2	-
T2R3	144
T3R1	188
T3R2	70

T3R3	166
T4R1	122
T4R2	263
T4R3	198
T5R1	180
T5R2	137
T5R3	322
T6R1	130
T6R2	73
T6R3	-

Table 6.6: Average pod per plant

Treatment	Number of pod
T1R1	4
T1R2	3.2
T1R3	3
T2R1	29.2
T2R2	-
T2R3	31
T3R1	16.5
T3R2	12
T3R3	14
T4R1	19
T4R2	24.9
T4R3	21
T5R1	25.9
T5R2	20
T5R3	21
T6R1	11
T6R2	9
T6R3	-

Table 6.7: Average pod per plot

Treatment	Number of pod
T1R1	40
T1R2	32
T1R3	30
T2R1	292
T2R2	-
T2R3	310
T3R1	165
T3R2	120
T3R3	140
T4R1	190
T4R2	249
T4R3	210

T5R1	259
T5R2	200
T5R3	210
T6R1	110
T6R2	90
T6R3	-

Table 6.8: Average yield per plant

Treatment	Yield (g)
T1R1	16.1
T1R2	13.1
T1R3	14
T2R1	88.3
T2R2	-
T2R3	91.4
T3R1	49
T3R2	43
T3R3	51
T4R1	63.1
T4R2	70.2
T4R3	66.1
T5R1	73.4
T5R2	70.2
T5R3	71.2
T6R1	36.2
T6R2	33.1
T6R3	-

Table 6.9: Average yield per plot

Treatment	Yield (g)
T1R1	161
T1R2	131
T1R3	140
T2R1	883
T2R2	-
T2R3	914
T3R1	490
T3R2	430
T3R3	510
T4R1	631
T4R2	702
T4R3	661
T5R1	734
T5R2	702
T5R3	712
T6R1	362
T6R2	331
T6R3	-

Figure:

Figure 6.1: Levelling process

Figure 6.2: Covering planting beds with silver shine plastic after NPK and compost have been applied

Figure 6.3: Seedling preparations

Figure 6.4: Front view of planting area

Figure 6.5: Flowering and fruiting of common bean

Figure 6.6: Overripe pod of common bean

Figure 6.7: Harvested pods