Effect of Bokashi on Growth and Yield of Yardlong bean (*Vigna unguiculata* var. *sesquapedalis)*

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DECLARATION

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

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I certify that the report of this final year project entitled "Effect of Bokashi on Growth and Yield of Yardlong bean (*Vigna unguiculata var. Sesquapedalis)*" by Nur Farihin Binti Aman Zuria, matric number F15A0142 has been examined and all correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Agrotechnology) with Honours, Faculty of Agro- Based Industry, Universiti Malaysia Kelantan.

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Effect on bokashi of growth yield of yardlong bean (*Vigna unguiculata* var. *sesquapedalis)*

ABSTRACT

Bokashi is one of the organic fertilizer made by fermenting organic matter with the addition of effective microorganism. Bokashi has been used in improving soil fertility in many countries and can improve the yield of many crops. The objective of this study was to determine the effect on different doses of bokashi on growth and yield of yardlong bean (*Vigna unguiculata* var. *sesquapedalis)*. This study used Randomized Block Design (RBD) with six treatments (0 kg, 2000 kg, 4000 kg, 6000 kg, 8000 kg bokashi, and 10000 kg compost per ha). All treatments were repeated three times. Result shows that bokashi 4000 kg per ha was the best dose for growth and yield of yardlong bean.

Keywords: *Bokashi, yardlong bean, growth, yield*

Kesan bokashi terhadap pertumbuhan kacang panjang renek (*Vigna unguiculata* var. *sesquapedalis)*

Abstrak

Bokashi adalah salah satu baja organik diperbuat melalui penapaian bahan organik dengan penambahan mikrorganisma berkesan. Objektif kajian ini adalah untuk menentukan kesan pada dos bokashi yang berlainan pada pertumbuhan dan hasil kacang panjang renek (*Vigna unguiculata* var. *sesquapedalis).* Bokashi telah digunakan untuk meningkatkan kesuburan tanah dalam beberapa buah negara dan dapat meningkatkan penghasilan banyak tanaman. Kajian ini menggunakan Reka Bentuk Blok Secara Rawak (RBD) dengan (0 kg, 2000 kg, 4000kg, 6000kg, 8000kg bokashi dan 10000kg kompos per ha). Semua rawatan diulang sebanyak tiga kali. Hasil kajian menunjukkan bahawa bokashi 4000 kg per ha adalah dos yang terbaik untuk pertumbuhan dan hasil kacang panjang renek.

Kata kunci: *Bokashi, kacang panjang renek, pertumbuhan, hasil*

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviation and symbols	Full Name
DMRT	Duncan's Multiple Range Test
EM	Effective Microorganisms
G	Gram
Ha	Hectare
Kg	Kilogram
NPK	Nitrogen-Phosphorus-Potassium
EM	Effective Microorganisms

CHAPTER 1

INTRODUCTION

1.1 Research Background

According to FAMA (1993), the per capita consumption of vegetables (exclude favouring category) in 1982 was 27.25 kg. Amongst the major vegetables, significant increases in per capita consumption between 1982 and 2001 were in sawi hijau (3.76 kg and 8.46 kg), cucumber (3.14 kg and 6.83 kg), cabbage (2.7 kg and 7.49kg), water spinach (1.68 kg and 4.47 kg), and Chinese spinach (1.75 kg and 3.64 kg). The growth in vegetable consumption is a good indication of the promising future growth in the vegetable sector. This is confirmed by Fatimah and Amna (2007), who suggested that per capita consumption of vegetables in Malaysia is expected to rise in view on the improvement in the standard of living and the growing health concern among the consumers.

One of the important economic growth crop in Malaysia is yardlong bean. It is considered to be relatively low pod yield because it is quite sensitive to adverse environmental conditions such as high temperatures, dry weather and even cloudy skies or heavy rain (Sarutayophat et al., 2007).

There were various uses of yardlong bean. The vegetables are delicious and good if picked before they reach full maturity. In soups, the overlooked beans are used. The beans and leaves also are good for birds, birds and little mammals "VeggiesInfo,"(2018).

Statistical reports The Malaysian Department of Agriculture showed a total of 3020 hectares in 2011, with an estimated total output of 41680 metric ton at RM 102.2 million. In Malaysia, there are about 7 long- bean varieties grown from seeds distributed by companies such as Eagle Seed (Sin Sin Huat), Leckat seeds and more. However, it is now believed that a sort of yardlong beans originated in the Philippines and were taken to southern Thailand before they were taken to northern Kedah (Anem, 2015).

In order to increase food production due to the demand nowadays, soil fertility amendment bokashi as compost is being applied in agricultural systems by utilize organic municipal waste and organic material as a manure. Composting is the biological decomposition and stabilization of organic substrates by mixed microbial population under optimum moisture, temperature and aeration conditions (Dalzell et al., 1987). However, compost properties vary widely depending on feeds and composting procedures (Bernal et al., 2009; Bertoldia et al.,1983).

Therefore, a research in to examining the effect of different doses of bokashi on the growth and yield of yardlong bean is needed. It is expected that the findings from this research can reduce the amount of compost application and the best dose of bokashi for yardlong bean can be obtained. Thus, farmers can apply bokashi with correctly doses to cultivate their crop.

1.2 Problem Statement

In conventional farming especially for vegetable cultivation farmers usually applied 10000 kg/ha of compost during preparation of bed. This is a large amount of compost. So, from this study is tried to reduce the use of compost bokashi application.

1.3 Hypothesis

After applying bokashi treatment may not have significant impact on growth and yield of yardlong bean and can also reduce of compost.

H0 : There is no effect on growth and yield of yardlong bean crops after applying bokashi.

H1 : There is effect on growth and yield of yardlong bean crops after applying bokashi

1.4 Objective

The objective of this study was to determine the effect on different quantity of bokashi on growth and yield of yardlong bean.

1.5 Research Question

a) Does different amount of bokashi affect the growth and yield of yardlong bean?

1.6 Scope of Research

This project is focusing on effect of different dose of bokashi. There are 6 treatments with different doses of bokashi including 0 kg per ha as negative control and 10000 kg of compost per ha as a positive control.

1.7 Significant of study

This study was to determine the best dose of bokashi on yardlong bean. With the suitable rate of bokashi, it will produce higher yield. For sustainable agricultural systems within small-scale farming, composting can be a good option for developing effective plant nutrient management strategies in many situations. Government should encourage farmers to use compost such as bokashi that can increase healthy crop growth.

1.8 Limitation of study

This research is limited by several factors. yardlong bean is quite sensitive to unfavourably environmental conditions, such as high temperature, dry weather, and even heavy rain. Due to this, it was easily infected by pests and diseases.

CHAPTER 2

LITERATURE REVIEW

2.1 Botany of yardlong bean

Yardlong bean belongs to family Fabaceae. It is known as vegetable cowpea, asparagus bean, string bean, snake bean, snake pea, snap pea, and so on. In Malaysia yardlong bean called as " kacang panjang renek " (Fana et al., 2004; Sarutayophat et al., 2007). Yard long bean originally found in West Africa was later extensively cultivated in many Southeast Asian countries, including Malaysia, the Philippines, Indonesia and Thailand.). Yardlong bean pods may grow to 10-20 cm long, but customers prefer them 10-12 cm in length and pencil-size (Benchasri et al., 2011; Benchasri et al., 2012).

The plants bloom in when the right time with a pair of large white or purple flowers. As indicated by Herklots (1972), it has three lobe leaves and long narrow pods and has a variable habit annually. Once pollinated, the flowers are followed by tiny dark green beans that reach 12 cm long in only a few days. According to Singh (1985), the flowers usually open early in the morning and close by noon. The flowers will fall off in

the same day. Although yardlong bean resembles pole snap beans (*Phaseolus vulgaris*), it is botanically more closely related to southern cowpeas (*Vigna ung*uiculata).

2.2 Agronomy of yardlong bean

Yard long bean is a warm-season crop. Temperatures for optimal growth are 27-30 °C. Heat and dry conditions are better tolerated than common field or lima beans (Rubatzky and Yamaguchi, 1997). According to Singh (1985), *Vigna unguiculata* sesquipedalis may be grown under less rainfall and more adverse conditions than *Phaseolus vulgaris*. It can be cultivated with moderate shade. The germination of seeds in the non- humid season should be planted in order to ensure stable growth. He added that *Vigna unguiculata* var *sesquipedalis* is almost completely self- pollinated as the main vectors by ants, flies and bees.

Yardlong bean tolerates acid soils but prefers soil pH range of 5.5 – 7.5. The plant thrives in soils that are loose, friable, and not too rich in nitrogen (Stephen, James M. 1994).

Despite the prospect of yardlong bean, high incidences of insect pests have reduced crop yields and poor quality. Farmers facing various problems especially in pests and diseases in cultivation of the crop such as pod borer, thrips, red mite, leaf miner, and leaf beetle (Rashid, 1993).

2.3 Taxonomy of yardlong bean

The complete of taxonomy of yardlong bean is as follow:

Phylum: Spermatophyta

Subphylum: Angiospermae

Class: Dicotyledonae

Order: Fabales

Family: Fabaceae

Subfamily: Papilionoideae

Genus: Vigna

Species: *Vigna unguiculata* var. *sesquipedalis*

Source: United States Department of Agriculture (USDA), 2017

2.4 Bokashi as added material

Efforts can be made to improve the soil condition by adding some organic matter such as bokashi to increase the soil's organic matter content meanwhile to increase the soil's ability to absorb and exchange nutrients in the soil. The application of inorganic fertilizer would therefore be more efficient because the nutrients released will be absorbed by the organic matter and made available to the plants so that the plants grow and develop

optimally and produce high yields. More than 2% of the soil's organic matter will generate additional agricultural systems (Hairiah et al., 2000).

Effective Microorganisms or EM is a blend of microorganisms, primarily lactic acid bacteria, coexisting in liquid media of pH of 3.5. It has been claimed that EM addresses a range of environmental concerns including water quality, the remediation of heavy metals from soil, and management in composting, however its prominent use is improving soil quality and plant growth in agricultural settings (Higa 2003). EM may be diluted and used as a spray to improve plant growth and suppress disease, but it is most effective when combined with organic materials to make bokashi, effectively decomposing wastes with no odor, giving way to the fermented soil conditioner (Higa, 1991).

Some studies have shown improvements in soil fertility and crop growth with bokashi applications, while others have reported negligible effects (Mayer et. al. 2010). For example, a study in China showed that EM bokashi treatments significantly increased grain yields, nutrient content in straw and grain, and straw biomass in wheat (Hu and Qi, 2013). Other than that, Gómez-Velasco et al. (2014) studied coffee growth and soil biological properties three organic compost, vermicompost and bokashi treatments. In the study, the bokashi was not inoculated with EM but with yeast. In bokashi treatments, the biggest increase in fresh shooting and root weight occurred.

Bokashi as a compost also provide organic acids that help to dissolve soil nutrients and make them available for the plants (Diwarkar, 2004). Additionally, other benefits of bokashi consist of increasing moisture retention in the soil, greater movement and availability of phosphorus and micronutrients due to complexation, improve soil structure with corresponding increase in infiltration rate and decrease in soil bulk density, also

increase buffering capacity against drastic changes in pH, and complexation of 3+ aluminium ion (Al) thereby reducing its toxicity (Tisdale et al, 1985).

The presence of this compost on the soil surface has some effects on soil physical properties such as reducing impact of rain drop on soil surface which might cause splash erosion. Also reducing evaporation and excessive heating and allowing microbiological activity to occur at optimum temperature (Uwizeyimana, 1997).

2.5 The nutrition of yardlong bean

Yard long bean is rich in protein, calcium, iron, riboflavin, phosphorus, potassium, and vitamin A. In addition, it is a very good source of vitamin C, folate, magnesium, and manganese (Asian Vegetable Research Development Center AVRDC, 2015; Yamaguchi, 1983; Hugque et al., 2012) Table 2.1 shows the nutrient content in yardlong bean.

Table 2.1: Nutrition content in yardong bean

Principle	Nutrient Value	Percentage of RDA
Energy	47 Kcal	2%
Carbohydrate	8.35 g	6%
Protein	2.8 g	5%
Total Fat	0.40	2%
Cholestrol	0 mg	0%
	Vitamins	
Riboflavin	**0.110 mg**	**9%**
Thiamin	**0.107 mg**	**9%**

Vitamin	**8.65 IU**	**29%**
	Minerals	
Calcium	**50 mg**	**5%**
Magnesium	**44 mg**	**11%**

CHAPTER 3

MATERIALS AND METHOD

3.1 Materials and equipment

The planting materials and equipment that was used in this experiment were:

- Yardlong bean seed (5 packs)
- Bokashi
- Hoe
- Measuring tape
- Silver shine plastic
- Balance
- Watering horse
- Chemical fertilizers NPK 15:15:15

Yardlong bean seed was used from Leckat seed. Bokashi was used as fertilizer at different dosage in this experiment. Seeds were sowed direct to the soil. Hoe and measuring tape were used during preparation of land. Then, silver shine plastic was seed to cover the plots. Last was bokashi as a fertilizer and chemical fertilizers NPK 15:15:15 were applied during preparation of plot.

3.2 Planting of yardlong bean

3.2.1 Land preparations

This project was conducted at Agropark UMK Jeli Kelantan. Test crop in this project was Yardlong bean. Land preparation was conducted one month before planting. The activities was started by land clearing and the weed also is cleared. The main purpose is to improve the structure of the soil (better ventilation, permeability and root zone loosening) in order to facilitate root penetration. There were 3 replication with 18 plots. Each replication contains 6 plots that were different treatment of bokashi dose. One plot was about 1.5cm width × 3.0m length. Each plot have 10 plants. Planting space was between 60cm x 40cm. Total number of plants that were planted are 180. The seed also was sown into the plot.

3.2.2 Bokashi and chemical fertilizer NPK application

All plots were applied with the same amount of fertilizer. Each plot were applied 75g NPK 15:15:15. The treatment in this experiment were the different dose of bokashi at 6 treatments. After applying bokashi and chemical fertilizer NPK is completed, the plot was covered with silver shine plastic. The aim used silver shine plastic is to control moisture content in bed and to control from weed growth.

3.2.3 Direct sowing

Yardlong bean were sown into the bed. The seed was sown 3 cm apart and 2 cm fine soil is covered. The germination seeds can be seen after five days. At the early stage, yardlong bean was watered twice daily early in the morning and late evening.

3.2.4 Harvesting

Yardlong bean can be harvest in week 6. The growth and development of yardlong bean was during 6 weeks. It can be harvested every two days afterwards. If beans are left to mature, plants will stop producing.

3.3 Experimental Details

3.3.1 Treatment

The treatment in this experiment was the different dose of bokashi at 6 treatments. The treatments were:

T1: 0 kg of bokashi per hectare (negative control)	=0 g per plot
T2: 2000 kg of bokashi per hectare	= 600 g per plot
T3: 4000 kg of bokashi per hectare	= 1200 g per plot
T4: 6000 kg of bokashi per hectare	= 1800 g per plot
T5: 8000 kg of bokashi per hectare	= 2400 g per plot
T6: 10000 kg of compost per hectare (positive control)	= 3000 g per plot

3.3.2 Layout of Experiment

The layout of this experiment is shown below.

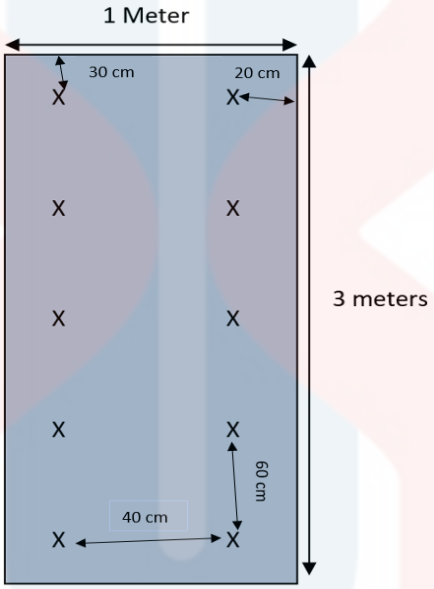

Figure 3.1: Experimental layout for one plot

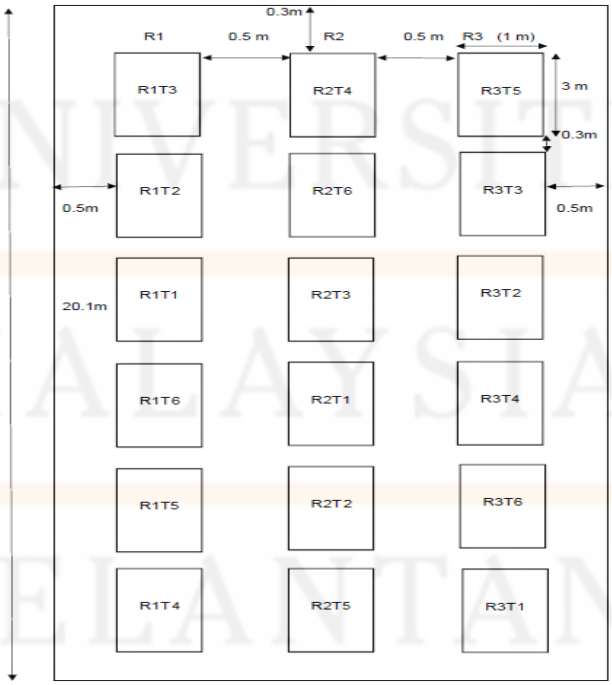

Figure 3.2: Experimental layout for all plot

3.4 Data collection

The growth and development of yardlong bean was observed follow the parameters that were plant height, total number of leaves, total number of branches, total number of flowers, total number of inflorescent, total yield per plot, total biomass. After harvested, yardlong bean were cleaned and weighed for biomass.

Plant height was measured in centimeter (cm). It was measured from root base to the highest shoot tips. Number of leaves was observed by calculating the leaves that open perfectly. Total yield was weighed after root was cut. Total biomass also obtained by weighing the overall parts of plants including roots. Total yield and total biomass was recorded in gram (g).

3.5 Experiment design

All data were analysed using One-way ANOVA in combined with Duncan's test utilizing programming SPSS and Microsoft Excel This experiment had one factor with six level. The design was arranged by using Randomize Block Design (RBD).

CHAPTER 4

RESULT AND DISCUSSION

4.1 Effect of bokashi on height of yardlong bean

Figure 4.1 shows the effect of bokashi on height of yardlong bean

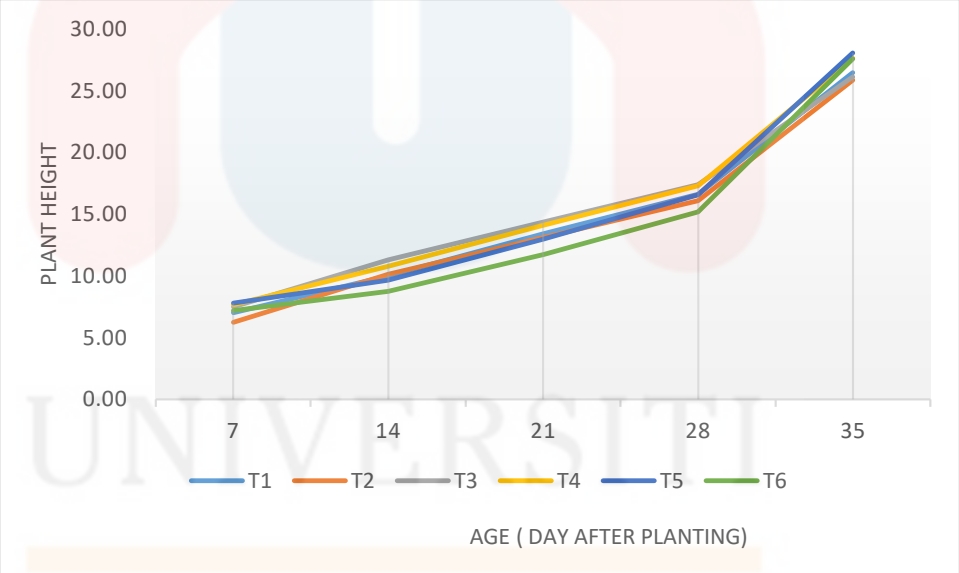

Figure 4.1: Height of Yardlong bean

Table 4.1: Effect of bokashi on height of yardlong bean

Treatment	**Height (cm) at day 35**
T1 = 0kg Bokashi/ha	26.4^{c}
T2 = 2000kg Bokashi/ha	27.6^{bc}
T3 = 4000kg Bokashi/ha	27.7^{bc}
T4 = 6000kg Bokashi/ha	30.4^{b}
T5 = 8000kg Bokashi/ha	34.6^{a}
T6 = 1000kg Compost/ha	30.1^{b}

Values followed by same letter is not significantly different based on DMRT for alpha 0.05

Figure 4.1 shows the highest of yardlong bean with different treatment of bokashi . The data was measured from week 1 until week 5 after transplanting. Every week, height of yardlong bean increases gradually. At the early stage, all treatments did not show any different between them. Treatment 5 shows good performance which is the highest average of height while treatment 1 showed least performance. For treatment 2, treatment 3, treatment 4 shows the average height is only slignificantly different between them.

Table 4.1, the highest value of plant height is treatment 5. The lowest value of plant height is treatment 1. The application of bokashi is clearly showed that effect number of height, number of leaves and other parameters (Soeparjono, 2016).

4.2 Effect of bokashi on number of leaves of yardlong bean

Figure 4.2 show the effect of bokashi on number of leaves of yardlong bean

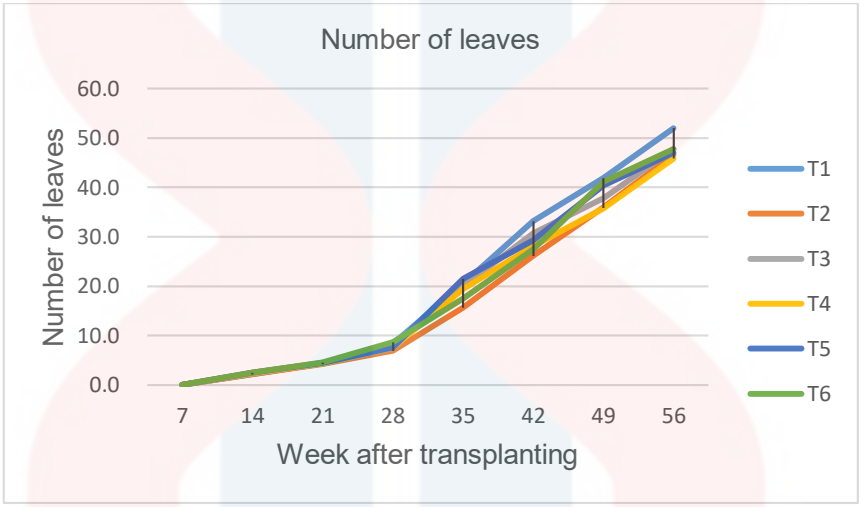

Figure 4.2: Number of leaves of yardlong bean

Table 4.2: Effect of bokashi on number of leaves

Treatments	**Leaves at day 42**
T1 = 0kg Bokashi/ha	4.4^{c}
T2 = 2000kg Bokashi/ha	4.5^{bc}
T3 = 4000kg Bokashi/ha	4.7^{abc}
T4 = 6000kg Bokashi/ha	5.4^{a}
T5 = 8000kg Bokashi/ha	5.3^{bc}
T6 = 10000kg Bokashi/ha	5.2^{bc}

Values followed by same letter is not significantly different based on DMRT for alpha 0.05

Figure 4.2 shows the number of leaves during 5 weeks after transplanting. For the first third week, the number of leaves do not show any effect at the early stage. Then, after week 3 all treatments started producing more number of leaves. The highest number

of leaves is belong to treatment 4 which is 5.4 that only slignificantly different with treatment 5 which is 5.2. This is due to the treatment 5 replicate 1, the plant get affected by diseases and producing less number of leaves. In this matter, bokashi would produce high number of leaves compared to the application of compost.

However, the data given in table 4.2 indicates significant different among treatments for number of leaves. The highest treatments is treatment 4. Next, the lowest treatments is treatment 1. Thus, there is significance different among treatment in producing number of leaves while treatment 5 and treatment6 showed not significant different.

Besides that, the higher number of leaves can relate to the yield in order to produce by yardlong bean. When the number of leaves increases, the more sunlight received. So, it can make photosynthesis well. This can be relate with the research by Soeparjono (2016), stated that leaves absorbed sunlight for photosynthesis process affect the production of ginger.

4.3 Effect of bokashi on number of branches of yardlong bean

Figure 4.3 shows the effect of bokashi on number of branches of yardlong bean

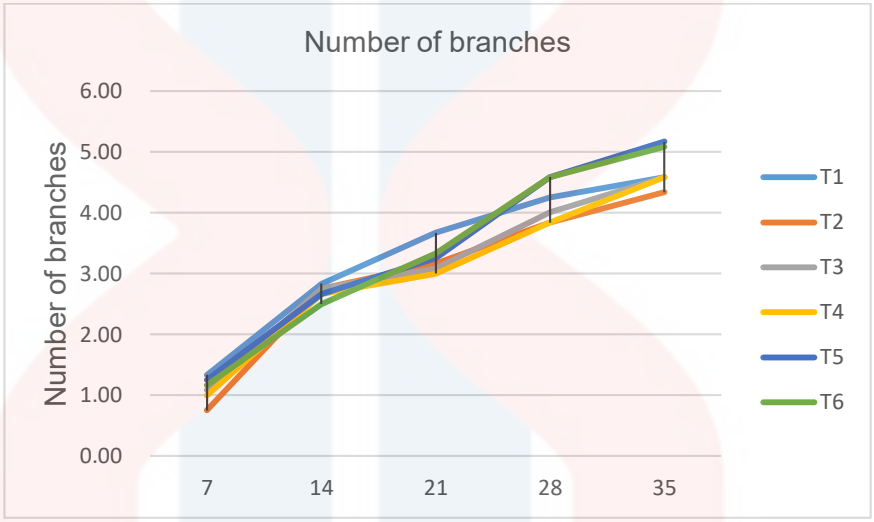

Figure 4.3: Number of branches of yardlong bean

Table 4.3: Effect on number of branches of yardlong bean

Treatment	Branches at day 21
T1 = 0kg Bokashi/ha	2.83[a]
T2 = 2000kg Bokashi/ha	2.70[a]
T3 = 4000kg Bokashi/ha	2.53[a]
T4 = 6000kg Bokashi/ha	3.03[a]
T5 = 8000kg Bokashi/ha	3.37[a]
T6= 10000kg Compost/ha	2.93[a]

Values followed by same letter is not significantly different based on DMRT for alpha 0.05

Figure 4.3 shows the number of branches of yardlong bean during 5 weeks after transplanting. After week 3, it begin to produce more number of branches. The highest number of branches had been achieved by Treatment 5. This can be figured out by application of bokashi can produce number of branches.

However, the data given in Table 4.3 shows that no significant differences among treatments for number of branches. The highest performance was Treatment 5. The highest number of branches was observed by Treatment 5 which are 3.37 that was no significant different from others treatment. Then, the less performance is treatment 3.

4.4 Effect on bokashi on total biomass

Table 4.4 shows the total biomass of yardlong bean.

Table 4.4. Effect of bokashi on total biomass of yardlong bean

Treatment	Total biomass (g)
T1 = 0kg Bokashi/ha	1256[b]
T2 = 2000kg Bokashi/ha	1441[b]
T3 = 4000kg Bokashi/ha	1344[a]
T4 = 6000kg Bokashi/ha	1646[ab]
T5 = 8000kg Bokashi/ha	1469[a]
T6= 10000kg Compost/ha	1532[a]

Values followed by same letter is not significantly different based on DMRT for alpha 0.05

Biomass was achieved to know the development of root. Roots crucial to determine the nutrients achieved by the soil. The higher the amount of biomass, the higher the weight of roots. From this data, the highest total biomass achieved by Treatment 4.

From the table 4.4, we can saw that the higher total biomass among bokashi treatment especially from Treatment while the lowest total biomass was obtained by Treatment 1.

From the table 4.4, Treatment 1 and Treatment 2 was not significantly different to each other but it significantly different to Treatment 3, Treatment 5 and Treatment 6.

4.5 Effect of Bokashi on yield of Yardlong bean

Table 4.5 shows the yield of yardlong bean plot

Table 4.5: Effect of bokashi on yield per plot of Yardlong bean

Treatment	**Yield per plot (g)**
T1 = 0kg Bokashi/ha	1842.67[b]
T2 = 2000kg Bokashi/ha	1861.00[b]
T3 = 4000kg Bokashi/ha	2840.00[a]
T4 = 6000kg Bokashi/ha	2592.77[ab]
T5 = 8000kg Bokashi/ha	3039.00[a]
T6= 10000kg Compost/ha	2826.08[a]

Values followed by same letter is not significantly different based on DMRT for alpha 0.05

Table 4.5 shows the yield of yardlong bean per plot. We can saw that Treatment 3, Treatment 4, Treatment 5, and Treatment 6 were not significantly affect each other in producing yield of yardlong bean. Among them, Treatment 3 produce height yield.

Therefore, any application of bokashi can be apply to achieve better yield instead of reducing the cost. Thus, Treatment 3 should be apply. Study by Lei Dou (2012) stated that application of bokashi increased yield of crop. The use of organic fertilizers such as bokashi can help to modify the plant microclimate, which in turn can optimally improve yardlong bean production. Organic matter can improve fertility, structure and will indirectly retain aggregation and porosity of the soil, which means it will maintain the soil's capacity to hold water (Forth, 1994).

Other than that, it also indicates that application of bokashi can improve soil conditions that favor plant growth, increase soil biological life and optimize the availability and the balance of nutrient cycling through nitrogen fixation, nutrient absorption, addition and cycling of external fertilizers. The availability of plant nutrients also is one of the factors affecting crop productivity.

Environmental factors are also believed to play a role in optimizing crop yardlong bean. The ability of yardlong bean to produce pods is highly dependent on interactions between plants and environmental factors. Organic materials have an important role in soil fertility, among others as a source of plant nutrients, forming a stable structure which has an influence on the growth and development of plants (Sabarudin et., al 2013)

CHAPTER 5

CONCLUSION AND RECOMMENDATION

In conclusion, application of bokashi showed a positive effect in production yardlong bean. Different amount of bokashi application significantly affects the growth development and yield of yardlong bean. Treatment 3 showed the best performance on the plant height, number of leaves and total yied per plot. Thus Treatment 3 produced high number of yield due to the treatment produce high output and available cost. While the least performance is Treatment 1 because of the lowest of plant height, number ofleaves, total yield per plot.

This research has given information on effect of different dosage of bokashi on the growth performance and yield production. So, it was good for farmers in order to increase the production growth ad yield of plant by applying bokashi fertilizer. If they have knowledge on the composting bokashi can produce it by themselves and they can reduce much of their cost.

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APPENDICES

APPENDIX A: List of tables

Table A1: Plant height

Treatment	Average Plant Height (cm)				
	Week1	Week2	Week3	Week4	Week5
T1R1	7.5	10.5	15.5	18.9	28.9
T1R2	6.1	8.7	12.0	14.9	28.8
T1R3	7.4	10.8	13.2	16.0	27.2
T2R1	3.8	10.9	14.0	47.6	27.1
T2R2	7.6	9.9	17.1	20.5	30.9
T2R3	7.3	9.2	12.5	15.8	28.2
T3R1	7.9	7.5	11.5	15.8	30.8
T3R2	6.5	9.5	13.6	16.6	28.1
T3R3	8.1	11.3	16.8	21.4	31.7
T4R1	8.6	14.0	17.5	24.3	29.5
T4R2	6.9	11.9	15.2	18.8	29.1
T4R3	7.9	11.9	17.4	22.9	32.5
T5R1	7.4	11.8	15.2	13.1	23.8
T5R2	8.0	11.6	14.8	18.3	29.0
T5R3	6.7	9.7	15.3	22.3	29.4
T6R1	8.3	10.4	15.8	19.8	30.5
T6R2	6.1	10.1	14.1	18.8	29.2
T6R3	7.1	10.9	15.5	21.5	30.5

Table A2: Number of leaves

Treatment	Number of Leaves							
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
T1R1	0.0	2.3	4.5	11.5	26.0	41.0	48.0	56.8
T1R2	0.0	2.3	4.3	7.3	17.3	26.0	36.8	48.5
T1R3	0.0	2.0	4.3	6.5	18.5	32.5	41.0	50.8
T2R1	0.0	2.5	4.3	7.0	11.3	20.0	30.3	40.5
T2R2	0.0	2.5	4.8	9.0	30.3	39.8	42.3	52.0
T2R3	0.0	2.3	4.3	6.8	17.0	24.5	35.0	45.0
T3R1	0.0	2.8	4.5	7.0	17.3	23.8	44.0	44.0
T3R2	0.0	2.5	5.0	12.3	18.3	34.3	44.5	54.3
T3R3	0.0	2.5	4.5	10.3	32.8	36.8	43.0	52.5
T4R1	0.0	2.8	5.3	9.3	26.8	38.0	45.8	54.5
T4R2	0.0	2.8	5.5	9.5	19.0	29.5	39.0	50.0
T4R3	0.0	2.5	5.5	10.0	21.8	36.3	45.8	55.8
T5R1	0.0	3.0	4.5	5.3	13.0	30.8	36.5	47.0
T5R2	0.0	3.0	5.8	11.0	41.3	43.0	50.8	60.5
T5R3	0.0	3.0	5.5	13.5	27.5	38.3	45.0	56.3
T6R1	0.0	3.0	5.3	8.0	31.5	24.0	39.5	52.0
T6R2	0.0	3.0	4.5	5.8	15.5	28.0	38.8	52.8
T6R3	0.0	3.0	5.8	12.3	36.0	43.8	51.3	62.8

Table A3: Number of branches

Treatment	Number of Branches				
	Week4	**Week5**	**Week6**	**Week7**	**Week8**
T1R1	2.0	2.5	4.0	5.3	5.5
T1R2	0.3	2.5	3.3	3.3	3.8
T1R3	1.8	3.5	3.8	4.3	4.5
T2R1	0.3	2.3	2.5	4.0	4.8
T2R2	1.3	2.5	3.0	3.8	4.5
T2R3	1.5	3.3	3.5	3.8	4.5
T3R1	1.0	2.3	3.3	6.3	6.5
T3R2	1.0	2.0	3.3	3.8	4.3
T3R3	1.8	3.3	3.3	3.5	4.5
T4R1	2.0	3.3	3.8	4.3	5.3
T4R2	0.8	3.3	4.0	4.3	4.8
T4R3	2.0	2.5	3.5	4.0	4.5
T5R1	1.5	2.5	3.3	3.8	5.0
T5R2	2.0	3.3	4.0	4.5	5.0
T5R3	2.5	4.3	4.8	4.8	5.0
T6R1	1.5	2.5	3.0	4.5	4.5
T6R2	1.8	2.5	3.0	3.5	4.3
T6R3	2.0	3.8	4.5	4.8	4.8

Table A4: Total biomass

Treatment	R1	R2	R3
T1	492	561	203
T2	545	485	411
T3	443	400	501
T4	537	544	565
T5	600	666	203
T6	522	500	510

Table A5: Total number of yield

Treatment	Total number of yield
T1R1	2139
T1R2	1447
T1R3	1942
T2R1	1315
T2R2	2061
T2R3	2207
T3R1	2456
T3R2	3497
T3R3	2567
T4R1	2337
T4R2	2494.3
T4R3	2947
T5R1	3232
T5R2	3029
T5R3	2856
T6R1	3072
T6R2	2301.3
T6R3	3105

APPENDIX B: Research Progress

Figure B1: Yardlong bean seeds

Figure B2: Land preparation

Figure B3: Covering the plot with plastic silver shine.