Observation on the Growth and Yield of *Hibiscus esculentus* (L.) Okra Using Bokashi

By

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A report submitted in fulfilment of the requirement for the degree of Bachelor of Applied Science (Agro technology) with Honours

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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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Student

Name:

Date:

I certify that the report of this final year project entitled “Observation on the Growth of *Hibiscus esculentus* (L.) Okra Using Bokashi by Nurul Nadihah Bt Abu Bakar, matric number F14A0313 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Agriculture Technology) with Honours, Faculty of Agro-Based Industry, Universiti Malaysia Kelantan.

Approved by:

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Supervisor

Name:

Date:

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Observation on the Growth and Yield of *Hibiscus esculentus* (L.) Okra Using Bokashi

ABSTRACT

A study on the growth and yield of *Hibiscus esculentus* (L.) Okra under different amount of Bokashi was held at Universiti Malaysia Kelantan, Jeli Campus Agropark. The aim of the study was to observe the growth pattern and yield of the plant and to fit the experimental data to logistic curve equation. The treatments consisted of; 10 000 kg compost/ha (positive control), 0 kg Bokashi/ha (negative control), 2 000 kg Bokashi/ha, 4 000 kg Bokashi/ha, 6 000 kg Bokashi/ha and 8 000 kg Bokashi/ha. This study used Randomized Block Design (RBD) that comprised factors by three replications. The treatments were applied once before the seed sowing. Data were collected on growth and yield parameters; plant height, plant leaves, plant branches, number of flowers, total fruit, yield per plot and yield per plant. The result showed that the vegetative growth of okra was the lowest without any application of Bokashi or compost. Bokashi positively influenced the vegetative growth of okra compared to the control treatments. In the generative data of okra, some Bokashi treatments performed poorer than the control treatments. Based on the findings of this experiments it can be concluded that, T3 (4 000 kg Bokashi/ha) promoted highest growth and yield of okra.

Keywords: *Hibiscus esculentus* (L.) Okra, growth, yield, Bokashi, compost

Pemerhatian terhadap Pertumbuhan dan Hasil *Hibiscus esculentus* (L.) Okra Menggunakan Bokashi

ABSTRAK

Satu kajian mengenai pertumbuhan dan hasil *Hibiscus esculentus* (L.) Okra (bendi) dalam jumlah Bokashi yang berbeza telah dijalankan di Taman Agro Universiti Malaysia Kelantan, Kampus Jeli. Tujuan kajian ini adalah untuk melihat corak pertumbuhan dan hasil tanaman serta memadankan data eksperimen pada persamaan kurva logistik. Rawatan terdiri daripada; 10 000 kg kompos / ha (kawalan positif), 0 kg Bokashi / ha (kawalan negatif), 2 000 kg Bokashi / ha, 4 000 kg Bokashi / ha, 6,000 kg Bokashi / ha dan 8 000 kg Bokashi / ha. Kajian ini menggunakan Reka Bentuk Rangka Rawak (RBD) yang terdiri daripada faktor-faktor dengan tiga ulangan. Rawatan tersebut diaplikasikan sekali sebelum menyemai benih. Data dikumpul berdasarkan parameter pertumbuhan dan hasil; ketinggian tumbuhan, jumlah daun, cawangan tumbuhan, bilangan bunga, jumlah buah, hasil setiap plot dan hasil setiap tumbuhan. Keputusan menunjukkan bahawa pertumbuhan vegetatif okra adalah yang paling rendah tanpa menggunakan bokashi atau kompos. Bokashi secara positif mempengaruhi pertumbuhan vegetatif okra berbanding dengan rawatan kawalan. Dalam data okra, beberapa rawatan Bokashi menunjukkan hasil yang kurang memberansangkan daripada rawatan kawalan. Berdasarkan penemuan daripada eksperimen ini, dapat disimpulkan bahwa secara numerik, T3 = 4 000 kg Bokashi / ha menghasilkan okra dengan pertumbuhan dan hasil yang terbaik.

Kata kunci: *Hibiscus esculentus* (L.) Okra, pertumbuhan, hasil, Bokashi, kompos

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LIST OF SYMBOLS & ABBREVIATIONS

≤ - Less than and equal to

= - Equal to

% - Percentage

g - Gram

kg - Kilogram

Ha - Hectares

cm - Centimetre

m - Metre

m^2 - Metre square

in - Inches

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Okra is a type of vegetable fruit that is very popular in hot climate countries especially Africa due to its edible green pod. Okra (*Hibiscus esculentus*) is also known as "gumbo" in Africa, although the latter term is more often used for soups or any dishes that use okra as the main ingredient. Other than eaten fresh, the pod can be cooked in many ways and contain various health benefits.

In Malaysia, the latest record for okra production is in 2014. Malaysia landed on the eleventh place in world production of okra with a total number of 45, 130 tons (Food and Agriculture Organization of the United Nations, 2014). Okra can be cultivated throughout the year and is very profitable. There is a great need for an increase in the production level of okra to generate more incomes for farmers and country.

Bokashi as an organic soil amendment that increase the crop yields by enhancing the soil fertility (Sangakkara et al., 1995). Bokashi promotes various vegetative and generative characteristics such as plant height, number of branches, number of leaves, number of fruits and number of seeds. Since the effectiveness of Bokashi has been tested on various crops with positive outcomes, the potential use of Bokashi as an alternate organic soil amendment should be studied.

However, the use of Bokashi as an alternative organic amendment is still not widely practiced compared to the standard 10 000 kg per hectare compost practice (Alexander, Rajan, Rajamony, Ushakumari & Kurien, 2009). The finding of this study will help to prove the effectiveness and determine the suitable amount of Bokashi applied with NPK fertilizer for the development of okra.

1.2 PROBLEM STATEMENT

The usage of Bokashi as another organic soil amendment has not yet widely practiced in farms compared to the practice of using compost that has been practiced for years and was very common among farmers for vegetable production. As Bokashi can bring more benefits to the crop production, a proper study was conducted to prove that Bokashi as an alternative organic soil amendment can perform just as good as or even better than the compost.

Besides, the effectiveness of the organic soil amendment may differ depends on the application on a different type of crop. Therefore, even if a Bokashi performs well on a certain crop, it is possible for it to give a different result on another plant.

Due to this, this study aims to determine the performance of Bokashi towards the production of okra. This study will also reveal the potential of Bokashi to reduce the consumption of compost base on its performance. Application of Bokashi will be combined with additional fertilization using NPK fertilizer.

1.3 OBJECTIVES

1. To observe the growth and yield pattern of okra under different amounts of Bokashi.
2. To fit the experimental data of growth of okra to logistic curve equation.

1.4 SIGNIFICANCE OF STUDY

This study was important to determine the best Bokashi treatment for productivity and growth rate of okra. Besides, this study will prove the potential of Bokashi as an alternate organic soil amendment that could replace the use of compost. Farmers and agro-entrepreneurs can refer this study in the future on the optimum application of Bokashi combined with the application of additional chemical fertilizer to produce higher yield and better growth of okra plant while improving and maintaining the soil fertility. Lastly, usage of Bokashi can be seen very profitable as it can increase the yield of okra.

CHAPTER 2

LITERATURE REVIEW

2.1 *Hibiscus esculentus* (L.) Okra

2.1.1 INTRODUCTION TO OKRA

Okra is a fruit vegetable grown in countries with hot humid climates such as ASEAN countries. Okra planted in Malaysia is said originally came from Central Africa. Now, it is commercially cultivated in Penang, Perak, Kelantan, and Johor. In Johor, 390 hectares of land was used for okra plantation in 2008 with the total produce of 1 620 metric tons per year. Okras are sold in markets including farmers' markets and vegetable markets.

Okra can be cultivated commercially and planted around the house either in a polybag or directly on the soil. 5-ridges and 7-ridges varieties are the most popular in Malaysia. Consumers in South Peninsula Malaysia prefer 5-ridges variety while consumers in North Peninsula Malaysia prefer 7-ridges variety.

2.1.2 TAXONOMY

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Malvales
Family	Malvaceae
Genus	*Hibiscus*
Species	*H. esculentus*

(Sources from Ministry of Science and Technology & Ministry of Environment and Forests Government of India)

2.1.3 ORIGIN AND DISTRIBUTION

Okra originated in tropical and subtropical regions of Africa. The secondary centre of okra origin is said to be India. This is due to the evidence of a large number of related species with wide variability and dominant characters.

The largest producer of okra in the world is India. Besides, okra is also used for various purposes in West Africa, Brazil and many other countries. Uttar Pradesh, Bihar and West Bengal are the major okra growing states in India.

2.1.4 MORPHOLOGY

Okra is a perennial species and is often cultivated in temperate climates as an annual. Without pruning, the semi-hard herbaceous okra plant can reach up to 4 meters. It is related to such species as hibiscus, cocoa and cotton. The stem is rounded, dark green in colour and does not have many branches. Okra is a single leaf type plant arranged spirally. The leaves are large about 10 to 20 centimetres (3.9–7.9 in) long and broad, palmately lobed with 3, 5 or 7 lobes. The diameter of the flowers are about 4 to 8 centimetres, with five white to yellow petals, often with a red or purple spot at the petals' base. The fruit capsule-like and the length can be up to 18 centimetres with a pentagonal cross-section, full of seeds. Okra fruit is green when young and turns chocolates when old.

Most of the cultivated varieties are amphidiploids with 2n=130. *H. esculentus* is known for its chromosome polymorphism and 2n ranges from 72 to 144. Okra able to tolerates addition or deletion of one or a few chromosomes. The chromosome number of *H. esculentus* is 2n=130 which is gained by the crossing of H*. tuberculatus* (2n=58) and *H. ficulneus* (2n=72) (Gopalakrishnan, 2007). The F_1 developed was subjected to colchicine treatment to make it amphidiploid, *H. esculentus* (2n=130).

2.1.5 POTENTIAL USE

Okra has various health benefits for human as it contains fibre, vitamins and minerals, including calcium, and vitamin C. Okra also very low in calories with no saturated cholesterol or fats. The edible green seed pod is the most valuable part of the plant. Okra is a very important vegetable for many types of soups. All tribes in Nigeria use okra to prepare their traditional meals or delicacies. Thus, it is a widely acceptable vegetable.

Okra can be easily dried for later used. A little dried okra can be prepared and consumed no differ that the fresh one. In Nigeria, seeds are prepared as a dish known as dandawan betso. In India, okra seeds are eaten in chutneys and curry. (Department of Agriculture, Forestry and Fisheries of Republic of South Africa, 2012).

Roasted okra seeds can be used to replace coffee after grounded. Once, it was widely used in Central America, Africa, and Malaysia. The leaves and immature fruit already been used in the East for a long time to relieve pain, moisturize skin, treat urinary disorders, prevent scurvy and induce sweating. The seed, root and flower broth mixed with sugar can be made as medicine syrup to treat a sore throat (Ong, 2003).

2.1.6 ECONOMIC VALUES

World production statistics revealed that Nigeria is the second largest producer of okra all over the world after India. It produced 2, 039, 500 tons of okra in the year 2014. The largest producer, India produced 9, 623, 718 tons of okra in the same year.

Malaysia scored the eleventh place in okra world production. This shows that there is a great need for an increase in the production level in Malaysia in other for us to have a surplus and thereby enable exportation. Farmers and agro-entrepreneurs must generate a higher yield of okra to maximize the profit.

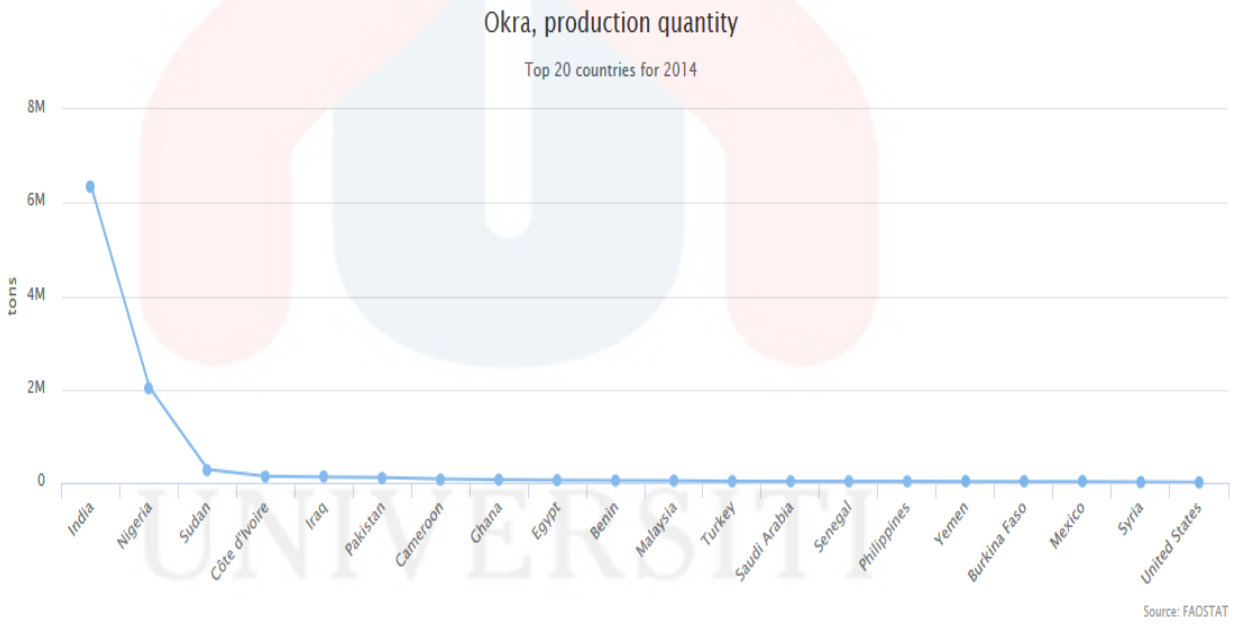

Figure 2.1: World Okra Production Quantity

(Source from Food and Agriculture Organization of the United Nations, 2014)

2.2 BOKASHI

2.2.1 INTRODUCTION TO BOKASHI

Bokashi is a biological fertilizer used as natural soil amendment. Bokashi term originated from Japan which means ‘organic matter that is fermented’. The host medium for Bokashi can be almost any fine organic materials for example, dried leaves, rice, bran and wheat mill run. This medium will be inoculated with beneficial microbes or effective microorganisms (EM). These beneficial microbes do not have a strong foul smell and flourish in anaerobic, acidic environment.

Beneficial microbes or Effective Microorganisms (EM) is a culture of mixed microorganism. It consists of yeast, lactic acid bacteria, fermenting fungi, photosynthetic bacteria and actinomycetes (Higa, 1998). EM for making Bokashi enhance soil fertility thus improving the yield of crops (Sangakkara et al., 1995).

A brew can be used to attract the appropriate bacterial strains as inoculant (Park & DuPonte, 2008). Later, the host material is immersed in the brew for microbes to ferment. Molasses act as microbes’ source of energy to reproduce wildly for several days. The inoculated host can be dried, packaged, and stored for long periods after the fermentation stage is over.

2.2.2 BOKASHI AS ORGANIC SOIL AMENDMENT

In anaerobic composting, usage of Bokashi as inoculant is not uncommon. Besides, the Bokashi can be added into aerobic compost file and directly added to the soil. The effectiveness of Bokashi as biological fertilizer has been proven with various crops. Soil with Bokashi application produces higher yield and provides better growth for the plant while improving the soil fertility.

In a study conducted by Mohamed, Elham, Mohamed and Hagagg (2007), Bokashi in both solid and solution form improved the yield and fruit quality of apple tree. Another study by Seran and Shahardeen (2013) on marketable pod yield of vegetable cowpea (*Vigna unguiculata*) as influenced by EM Bokashi showed similar results. However, the different manures contained in the EM Bokashi gave different result in terms of pod yields, the dry weight, number of nodules and leaf area. The difference could be due to the different nutritional contents.

Milagrosa and Balaki (1996) found that the yield and growth of vegetable lettuce with the application of NPK fertilizer, Bokashi and EM combined recorded the best result compared to the Bokashi, EM and chemical fertilizer application alone. The same result can be applied to the finding by Quansah (2010) in which usage of combined organic and chemical fertilizer did produce a better result on the crop.

The use of Bokashi could have improved the soil fertility as the excessive usage of chemical fertilizer has shown negative impacts to soil quality. Habi (2012) stated that Bokashi waste addition increased P availability in soil and P uptake by the plant. Bokashi also increased the total microorganism in soil and some cations available in soil (N, P, K, Fe, Zn, and Mn) (Sheren Adel Abed El-Hamied, 2014).

CHAPTER 3

METHODOLOGY

3.1 PLANT MATERIAL

Seeds of F1 Hybrid Okra 304 from the brand Green World were used. The okra seeds were produced by Green World Genetics Sdn. Bhd.. The five ridges okra can grow particularly well in tropics.

3.2 BOKASHI

The Bokashi fertilizer used was bought from the factory of Dairy Industry Service Center (PPIT) Pasir Puteh, Kelantan.

3.3 LAND PREPARATION

This study was conducted in the Agropark of University Malaysia Kelantan, Jeli Campus from August 1st 2017 until October 23rd 2017. The previously unused land was cleared and ploughed thoroughly. All the plant beds were prepared manually using basic farming tools such as hoes and spades. The application of basal fertilizers such as NPK 10:10:10, CIRP and urea as well as the treatments were done after the beds were readied and later they were covered with silver shine plastic.

3.4 EXPERIMENTAL LAYOUT AND TREATMENT APPLICATION

The spacing of the okra seeds was 60cm x 60cm. Giving 100 cm (1.0 m) plot width and 300 cm (3.0 m) plot length, the plot has 2 rows and the number okra seeds per row were 5. In total, each plot has 10 plant units. Therefore, area of the plot was 3.0 m x 1.0 m giving 3.0 m^2.

This study used Randomized Block Design (RBD) that comprised all the factors by 3 replications. Six levels of treatment were used in this study, thus the total of 18 plots were built to accommodate all plant units.

The levels of treatment were shown as below;

T1 = 0 kg of Bokashi/Ha

T2 = 2 000 kg of Bokashi/Ha

T3 = 4 000 kg of Bokashi/Ha

T4 = 6 000 kg of Bokashi/Ha

T5 = 8 000 kg of Bokashi/Ha

T6 = 10 000 kg of compost/Ha

Details of the experimental layout were shown in the figure below.

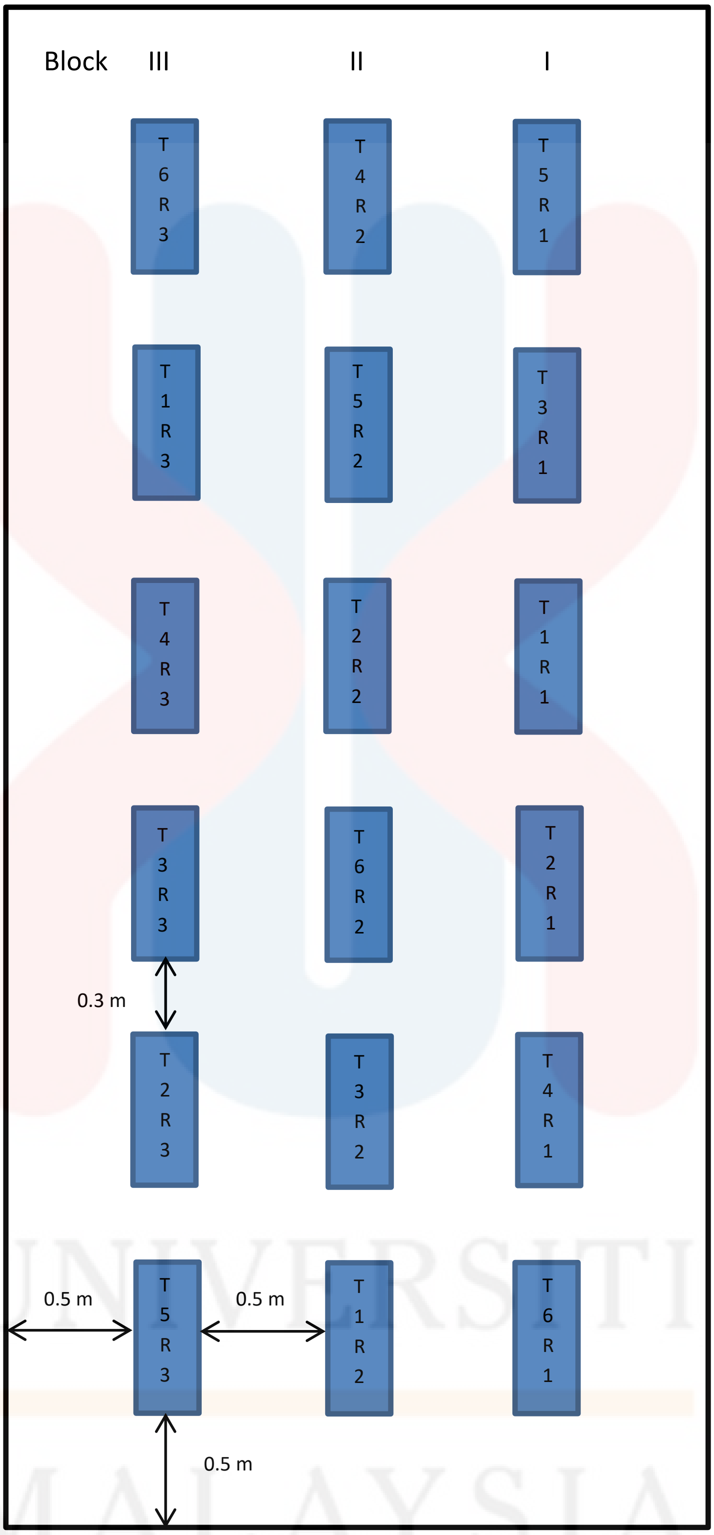

Figure 3.4 Experimental Layout

3.5 DATA COLLECTION

Several dependant variables were collected along the study. The vegetative data record started after seven days of seed sowing while the generative data were only taken when the plants produced flowers.

Below is the list of dependant variable;

1) Vegetative data
   i. Plant Height
   ii. Number of Leaves
   iii. Plant Branches
2) Generative data
   i. Number of flowers
   ii. Total Fruits
   iii. Yield per Plant
   iv. Yield per Plot

3.6 DATA ANALYSIS

The data of effect of the different amount of Bokashi on the variables were subjected to one-way ANOVA. To compare the mean among the control and treatments groups at 5% level of significant, the Duncan test as a post-hoc test (multiple comparisons) was used.

CHAPTER 4

RESULT AND DISCUSSION

4.1 PLANT HEIGHT

Table 4.1 below presented the mean height of okra plants at maturity. The result showed that those okra plants fertilized with Bokashi were higher compared to the untreated and plants treated with compost. This was due to the presence of Bokashi fertilizer that enhanced the growth of the crop (Yashiro, 2009). Poor vegetative character observed in untreated okra plants confirmed a study that nutrients absence affects the growth of the plant (Akanbi & Togun, 2003). Application of T3 (4 000 kg of Bokashi/ha) gave the tallest plant, followed closely by T2 (2 000 kg of Bokashi/ha).

Table 4.1 Plant Height

Treatment	Plant Height (cm)
T1 = 0 kg of Bokashi/ha	63.417
T2 = 2 000 kg of Bokashi/ha	91.160
T3 = 4 000 kg of Bokashi/ha	93.750
T4 = 6 000 kg of Bokashi/ha	79.083
T5 = 8 000 kg of Bokashi/ha	74.583
T6 = 10 000 kg of Compost/ha	70.833

Means sharing the same letters are not significantly different at ($P \leq 0.05$) according to Duncan's test.

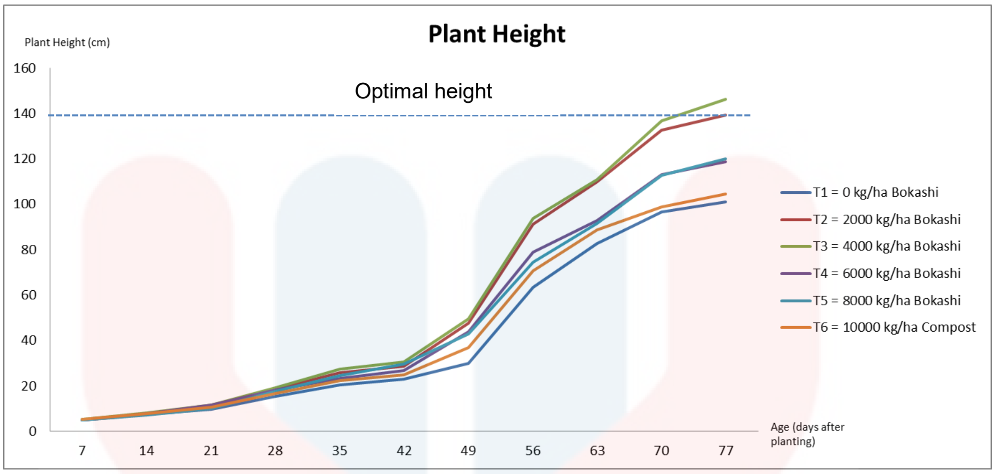

Figure 4.1 Plant Height

The Figure 4.1 above showed weekly observed height of okra plants. The highest plants were resulted by T3 (4 000 kg of Bokashi/ha). The line in the graph at 140 cm height was the average maximum height of okra plant with the application of basal fertilizer based on okra basic nutrients requirement (Nair, Hebbar, Prabhaker & Rajeshwari, 2017). From the graph, only plant from T2 (2 000 of of Bokashi/ha) and T3 (4 000 kg of Bokashi/ha) surpassed the line proving that the treatment bring the best impact on okra height. The plant with Bokashi application constantly showed positive response every week as the EM technology that contained bacterial culture in Bokashi that dispersed the organic matters faster (Wijayanto, Zulfikar, Tufaila, Sarman & Zamrun, 2016).

4.2 NUMBER OF LEAVES

In the Table 4.2, the means total number of leaves at maximum were shown. The table showed that T3 (4 000 kg of Bokashi/ha) produced the most number of leaves while the least number of leaves produced by T1 (0 kg of Bokashi/ha) followed by T6 (10 000 kg of compost/ha). T2 (2 000 kg of Bokashi/ha), T5 (8 000 kg of Bokashi/ha) and T4 (6 000 kg of Bokashi/ha) showed results that did not differ much from T3 (4 000 kg of Bokashi/ha). Wijayanto, Zulfikar, Tufaila, Sarman and Zamrun (2016) stated in their research that application of Bokashi did increase the number of leaves.

Table 4.2 Number of Leaves

Treatment	Total Number of Leaves
T1 = 0 kg of Bokashi/ha	19.08[a]
T2 = 2 000 kg of Bokashi/ha	25.00[a]
T3 = 4 000 kg of Bokashi/ha	25.58[a]
T4 = 6 000 kg of Bokashi/ha	21.77[a]
T5 = 8 000 kg of Bokashi/ha	24.00[a]
T6 = 10 000 kg of Compost/ha	20.92[a]

Means sharing the same letters are not significantly different at ($P \leq 0.05$) according to Duncan's test.

The graph in Figure 4.2 below showed weekly number of leaves observed every week since seven days after planting. Every week until the leaves started to fall, the plants with application of Bokashi have the most number of leaves as the Bokashi stimulated plant growth and provided rapid effect on plants (Wijayanto, Zulfikar, Tufaila, Sarman & Zamrun, 2016)

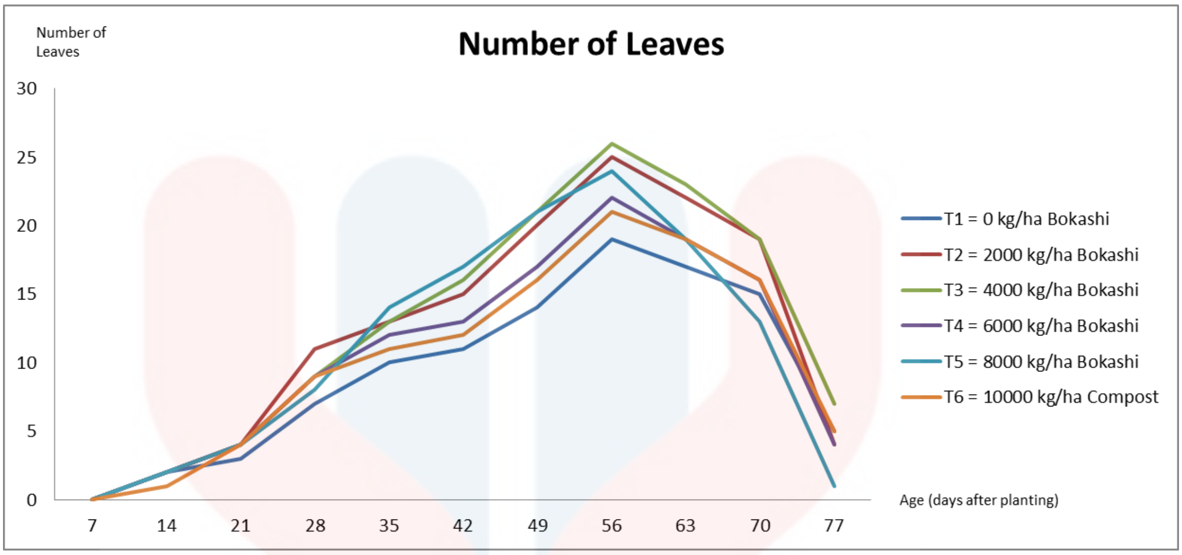

Figure 4.2 Number of Leaves

4.3 PLANT BRANCHES

In Table 4.3, T2 (2 000 kg of Bokashi/ha) showed the highest number of productive branches compared to the other treatments. High number of productive branches on crop plant was a result of Bokashi treatment according to Wijayanto, Zulfikar, Tufaila, Sarman and Zamrun (2016). All Bokashi treatments showed good result compared to T1 (0 kg of Bokashi).T1 (0 kg of Bokashi) produced the lowest number of productive branches due to the lack of nutrients (Akanbi & Togun, 2003).

Table 4.3 Plant Branches

Treatment	Total Number of Branches
T1 = 0 kg of Bokashi/ha	1.58[a]
T2 = 2 000 kg of Bokashi/ha	2.67[a]
T3 = 4 000 kg of Bokashi/ha	2.58[a]
T4 = 6 000 kg of Bokashi/ha	2.42[a]
T5 = 8 000 kg of Bokashi/ha	1.92[a]
T6 = 10 000 kg of Compost/ha	2.17[a]

Means sharing the same letters are not significantly different at ($P \leq 0.05$) according to Duncan's test.

In the Figure 4.3, it can be seen that T2 (2 000 kg of Bokashi/ha) and T3 (4 000 kg of Bokashi/ha) resulted the same number of productive branches. However, other Bokashi applications produced the same amount of productive branches as T1 (0 kg of Bokashi/ha) and T6 (10 000 kg of compost/ha)

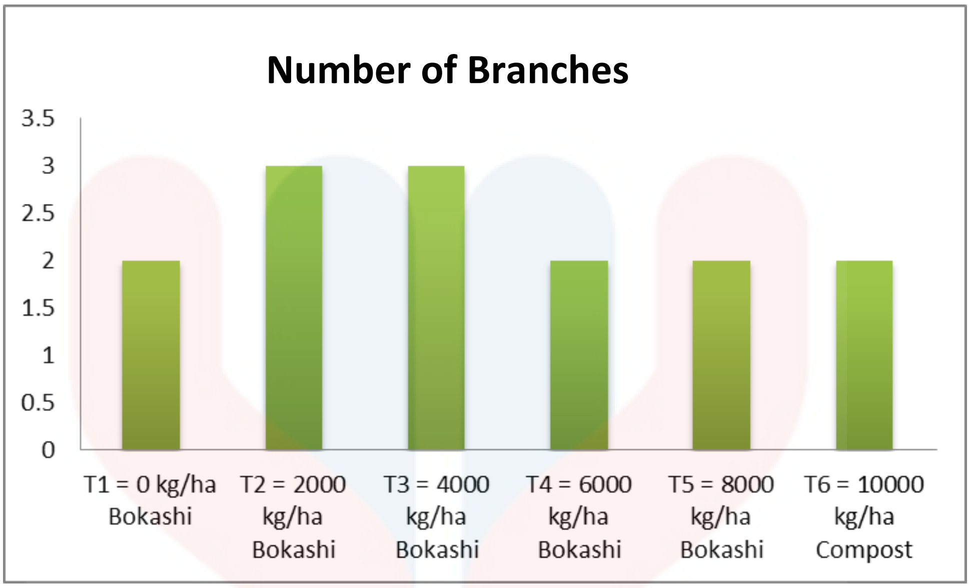

Figure 4.3 Plant Branches

4.4 NUMBER OF FLOWERS

Table 4.4 showed the mean number of flowers per week. Plants fertilized with Bokashi gave more flowers compared to plants fertilized with compost. T6 (10 000 kg of Compost/ha) gave the least number of flowers followed T1 (0 kg of Bokash/hai) and T5 (8 000 kg of Bokashi/ha) with the same number of flowers. Based on the table, statistically, T1 (0 kg of Bokashi/ha) produced more flowers than T6 (10 000 kg of Compost/ha). This outcome was contrary to that of Afroz Naznin et. Al (2015) who found that application of Bokashi and compost improved the flowering of crop.

Table 4.4 Total Number of Flowers

Treatment	Total Number of Flowers
T1 = 0 kg of Bokashi/ha	3.5^{a}
T2 = 2 000 kg of Bokashi/ha	4.25^{a}
T3 = 4 000 kg of Bokashi/ha	5.33^{a}
T4 = 6 000 kg of Bokashi/ha	4.5^{a}
T5 = 8 000 kg of Bokashi/ha	3.5^{a}
T6 = 10 000 kg of Compost/ha	3.42^{a}

Means sharing the same letters are not significantly different at (P≤0.05) according to Duncan's test.

In the Figure 4.4, the graph showed the mean number of flowers from the previous data (Table 4.4). The graph indicated that the best response was resulted from application of 4 000 kg Bokashi per hectare.

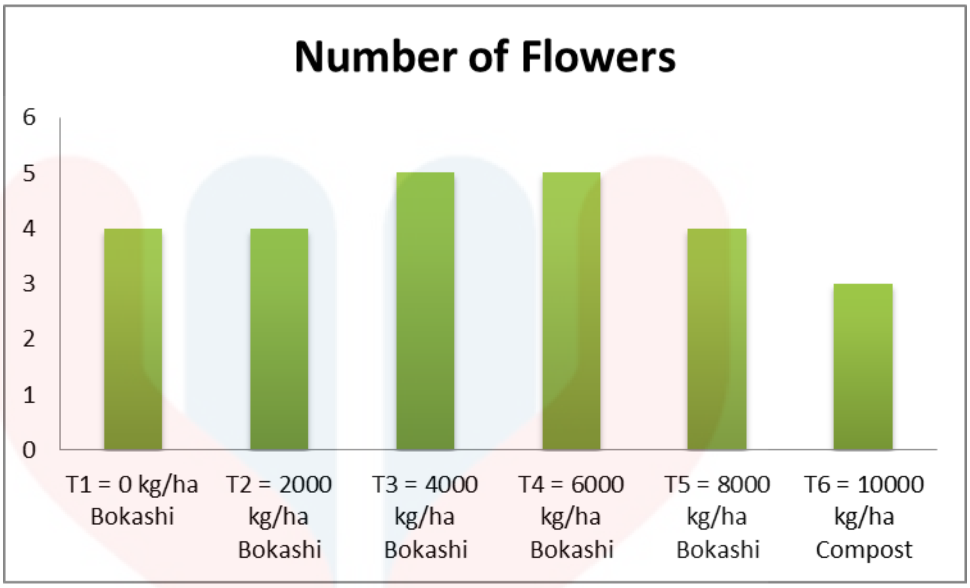

Figure 4.4 Number of Flowers

4.5 TOTAL FRUIT

In Table 4.5, the result indicated that T3 (4 000 kg of Bokashi/ha) gave the best total number of fruit per harvest. The second highest number of fruit per harvest was T6 (10 000 kg of compost/ha) followed by T4 (6 000 kg of Bokashi/ha) T2 (2 000 kg of Bokashi/ha) and T1 (0 kg of Bokashi/ha). Okra plant with application T5 (8 000 kg of Bokashi) produced the smallest number of fruit. Research conducted by Wijayanto, Zulfikar, Tufaila, Sarman and Zamrun (2016) found that Bokashi affect the number of fruit. Another research by Adebayo, Shokalu and Akintoye (2013) found that compost treatment gave higher number of fruit, higher growth and better yield value compared to the untreated plot. However the result of T5 (8 000 kg of Bokashi/ha) resulting fewer number of fruit that has not T1 (0 kg of Bokashi /ha) previously been described.

Table 4.5 Total Fruit.

Treatment	Total Fruit
T1 = 0 kg of Bokashi/ha	11.37[a]
T2 = 2 000 kg of Bokashi/ha	14.77[a]
T3 = 4 000 kg of Bokashi/ha	19.93[a]
T4 = 6 000 kg of Bokashi/ha	15.53[a]
T5 = 8 000 kg of Bokashi/ha	9.2[a]
T6 = 10 000 kg of Compost/ha	16.17[a]

Means sharing the same letters are not significantly different at ($P \leq 0.05$) according to Duncan's test.

In the mean number of fruit per harvest (Figure 4.5), it can be seen that T5 with the application of 8 000 kg Bokashi per hectare gave the least impressive number of fruit while T3 with the application of 4 000 kg of Bokashi per hectare gave the most number of fruit.

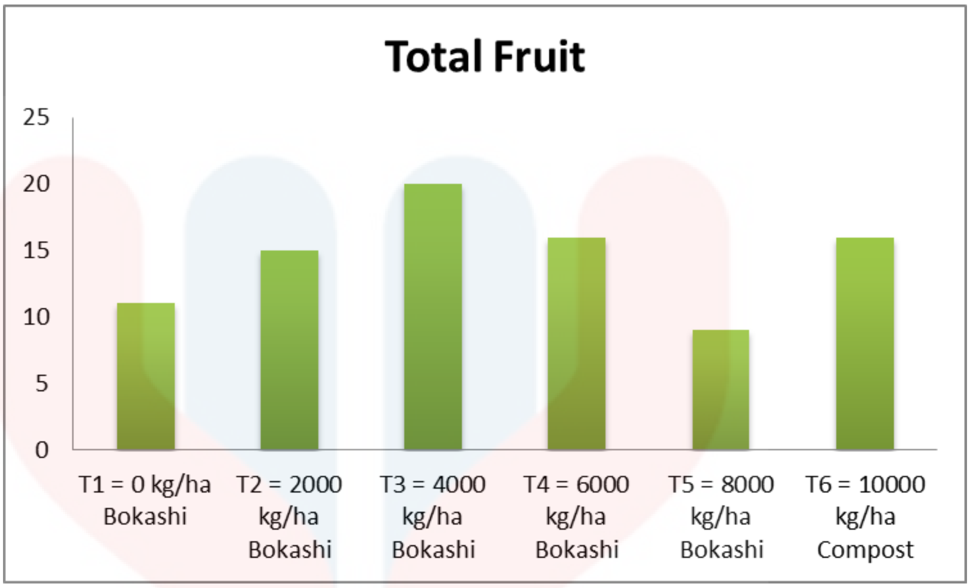

Figure 4.5 Total Fruit

4.6 YIELD PER PLOT AND YIELD PER PLANT

From the Table 4.6.1, the highest yield per plot was resulted from T3 (4 000 kg of Bokashi/ha) followed by T4 (6 000 kg of Bokashi/ha), T2 (2 000 kg of Bokashi/ha), T6 (10 000 kg of Compost/ha) and T1 (0 kg of Bokashi/ha). The lowest yield per plot came from T5 (8 000 kg of Bokashi/ha). Bokashi fertilizer enhanced the soil fertility, improve biological properties and physical amelioration of soil structure thus, increasing the yield per plot (Vetayasuporn, 2006). Compared to plot with no Bokashi application, plot with Bokashi fertilizer able to produce high marketable yield of crop (Seran & Shahardeen, 2013). This finding was supported by a latest study by Wijayanto, Zulfikar, Tufaila, Sarman and Zamrun, (2016) that Bokashi improved the soybean yield. Besides, it was also mentioned before that compost application also improved the value of yield (Adebayo, Shokalu and Akintoye, 2013). Similar to the previous variable, T5 (8 000 kg of Bokashi/ha) performed poorly compared to T1 (0 kg of Bokashi/ha).

Table 4.6.1 Yield per Plot

Treatment	Yield per plot (g)
T1 = 0 kg of Bokashi/ha	2187.7[a]
T2 = 2 000 kg of Bokashi/ha	3045.7[a]
T3 = 4 000 kg of Bokashi/ha	3246.0[a]
T4 = 6 000 kg of Bokashi/ha	3168.7[a]
T5 = 8 000 kg of Bokashi/ha	2107.0[a]
T6 = 10 000 kg of Compost/ha	2643.7[a]

Means sharing the same letters are not significantly different at (P≤0.05) according to Duncan's test.

The graph below (Figure 4.6.1) showed that yields from T4 (6 000 kg of Bokashi/ha) and T2 (2 000 kg of Bokashi/ha) did not differ much from the highest (T3 = 4 000 kg of Bokashi/ha).

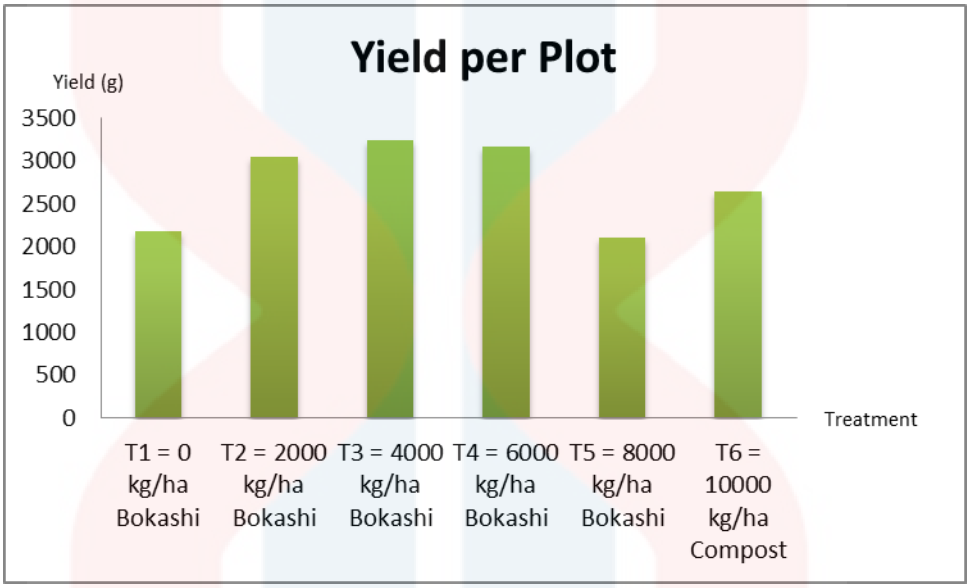

Figure 4.6.1 Yield per Plot

In the table mean yield per plant (Table 4.6.2), the data showed similar trend to the previous data, total fruit (Table 4.5). The highest yield came from okra plant treated with 4 000 kg of Bokashi per hectare followed by T6 (10 000 kg of compost/ha), T4 (6 000 kg of Bokashi/ha), T2 (2 000 kg of Bokashi/ha) and T1 (0 kg of Bokashi/ha). Okra plant with application T5 (8 000 kg of Bokashi/ha) produced the smallest number of yield. The possible explanation for poor performance of T5 (8 000 kg of Bokashi/ha) in some variables were probably due to the plant did not get much benefit except for the vegetative growth when T3 (4 000 kg of Bokashi/ha) gave the optimum benefit for generative and vegetative growth respectively. Yoshiro (2009) stated that Bokashi gave different effect on plant depend on the quantity and material used. However, this founding performance of T5 (8 000 kg of Bokashi/ha) need further study.

Table 4.6.2 Yield per Plant

Treatment	Yield per Plant (g)
T1 = 0 kg of Bokashi/ha	261.267[a]
T2 = 2 000 kg of Bokashi/ha	297.133[a]
T3 = 4 000 kg of Bokashi/ha	431.6[a]
T4 = 6 000 kg of Bokashi/ha	337.333[a]
T5 = 8 000 kg of Bokashi/ha	208.533[a]
T6 = 10 000 kg of Compost/ha	357.1[a]

Means sharing the same letters are not significantly different at ($P \leq 0.05$) according to Duncan's test.

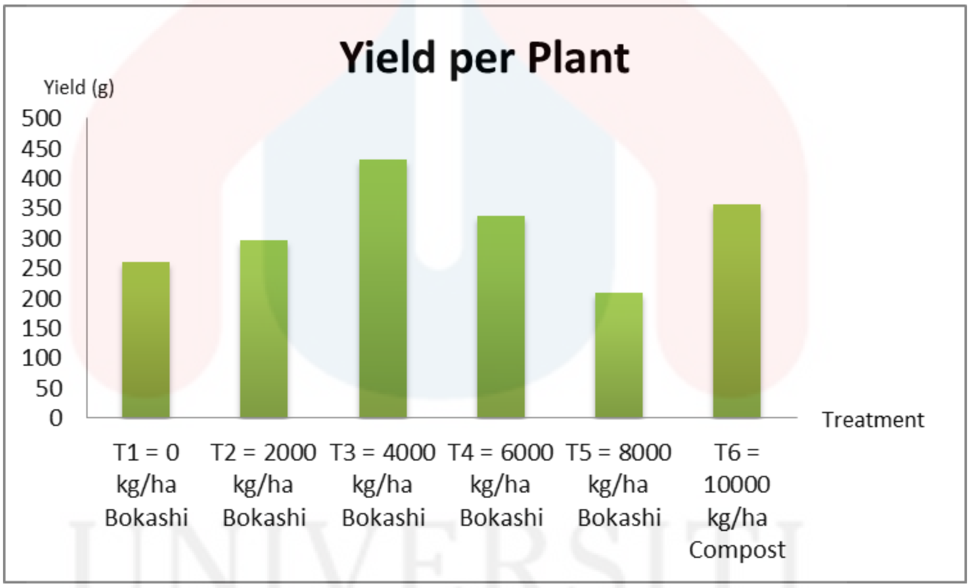

Figure 4.6.2 Yield per Plant

The Figure 4.6.2 above showed that T3 (4 000 kg of Bokashi/ha) gave the best response out of all levels of treatment.

4.7 CORRELATION

The correlation graph was made to investigate the relationship between okra height and several variables that included the vegetative and generative growth.

a)

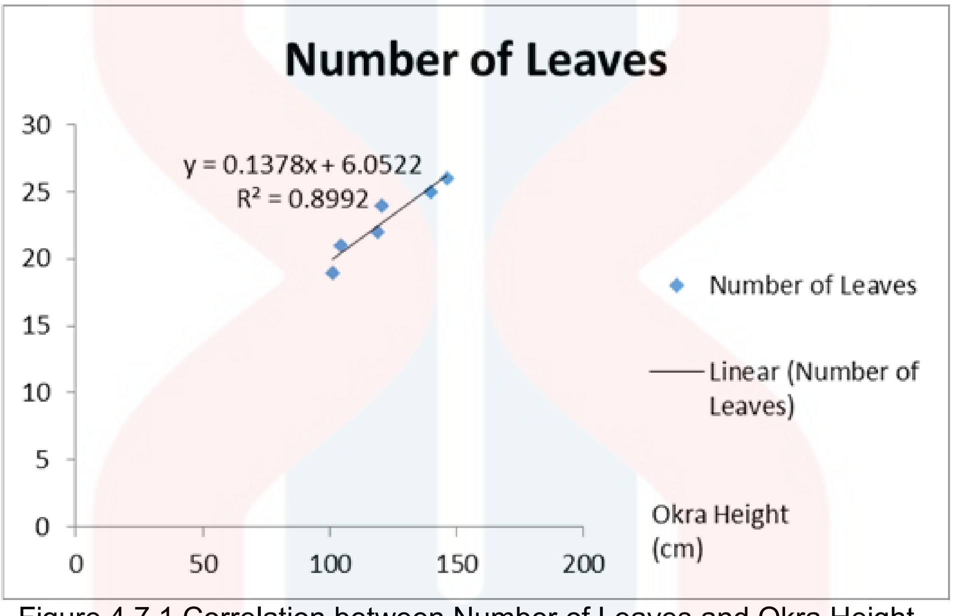

Figure 4.7.1 Correlation between Number of Leaves and Okra Height

b)

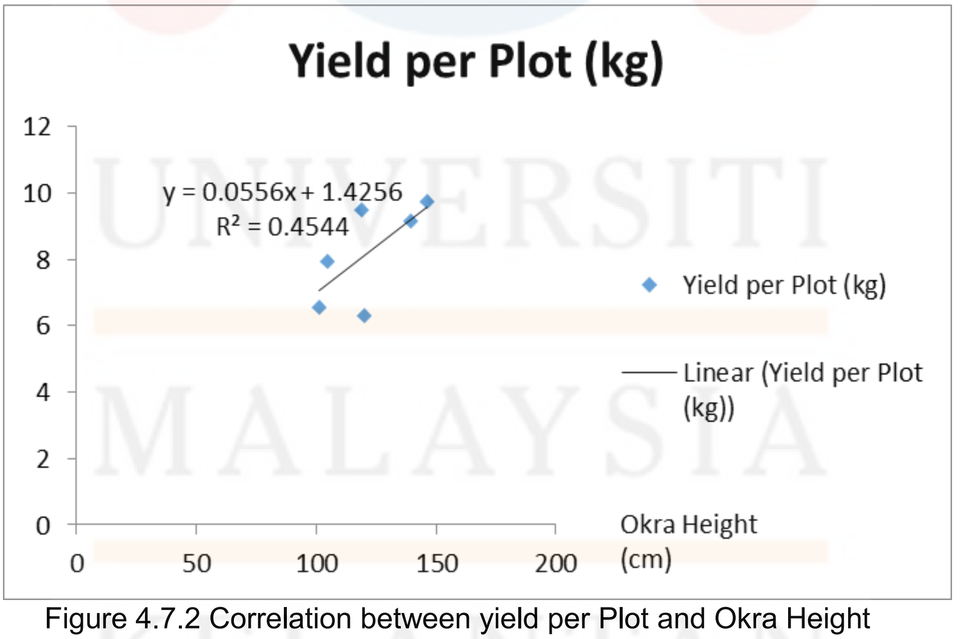

Figure 4.7.2 Correlation between yield per Plot and Okra Height

c)

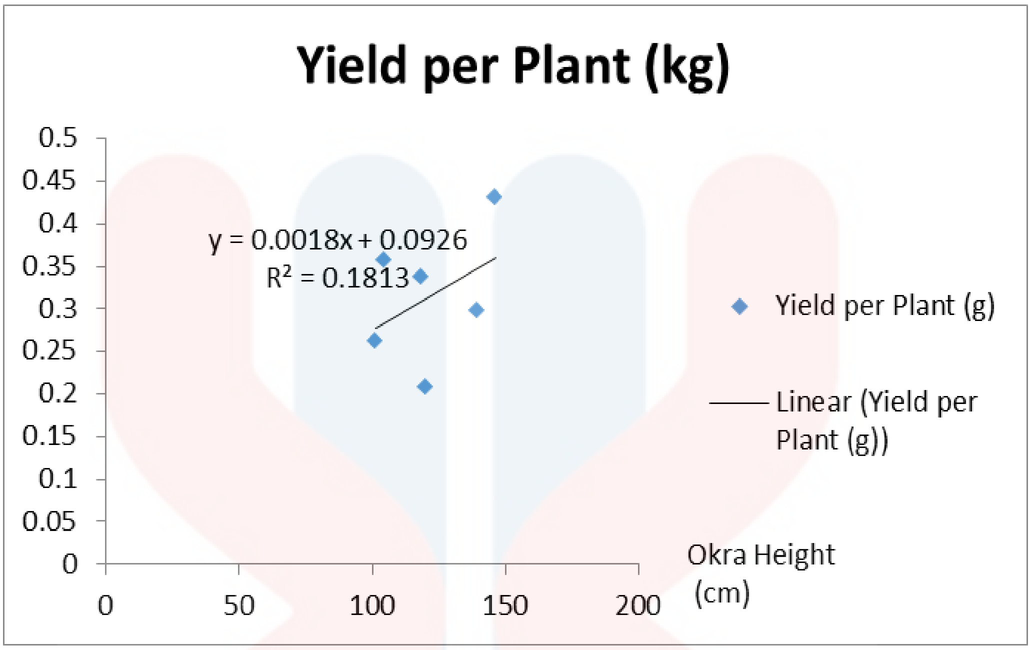

Figure 4.7.3 Correlation between Yield per Plant and Okra Height

d)

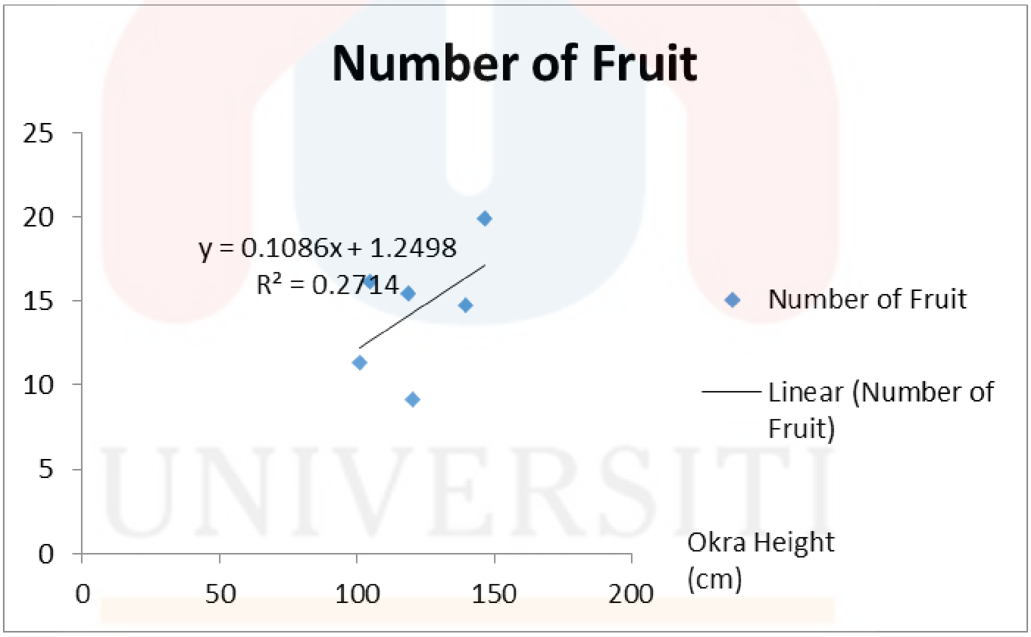

Figure 4.7.4 Correlation between Number of Fruit and Okra Height

Figures above showed correlation between parameters and height. From the graphs, number of leaves, yield per plot (kg), yield per plant (kg) and the number of fruit did have positive correlation with the okra height. The R value in Figure 4.7.1 was 0.8992. The close R value to 1 proved that there was a strong correlation between okra height and the number of leaves. The R values in Figure 4.7.2, Figure 4.7.3 and

Figure 4.7.4 were 0.4544, 0.1813 and 0.2714 respectively. There were positive correlation between okra height and all the variables. However, as the numbers were quite far from value 1, the correlations were weak. The results support a research by Iyagba, Onuegbu and Ibe in 2013 that higher plant height leads the growth of leaves, number of fruits and higher yield. This was due to the effect of nitrogen content in soil.

4.8 FITTING DATA TO GROWTH CURVE MODEL

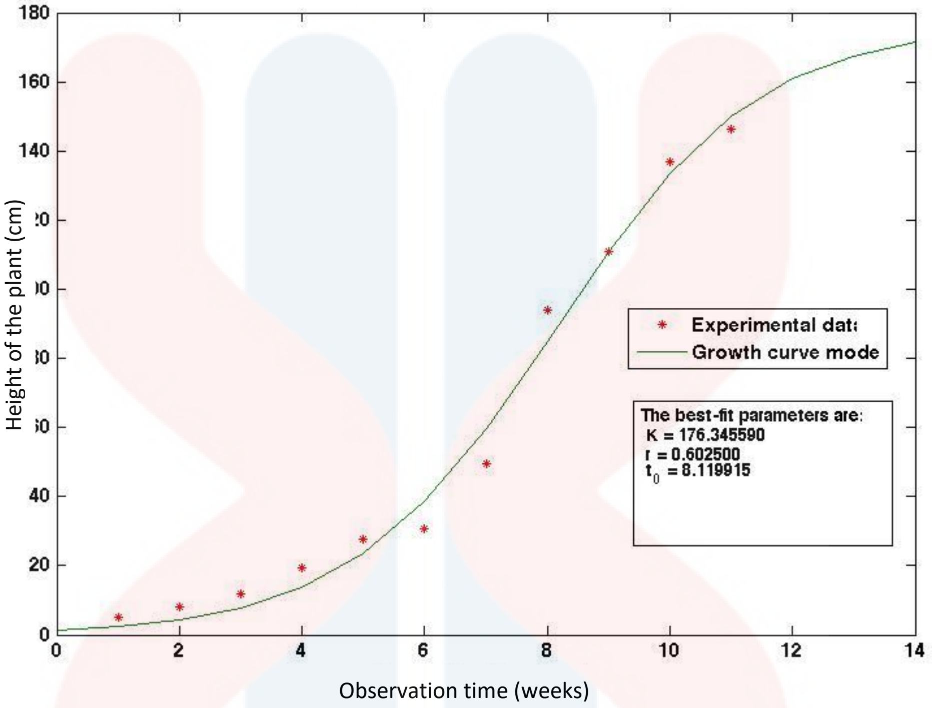

Figure 4.8 Growth Curve Model

Figure above shows the fitted experimental data to the Growth Curve Model. It is a logistic function or logistic curve where it has a common "S" shape (sigmoid curve), with equation:

$$y = \frac{K}{1 + e^{-r(t-t_0)}}$$

Where *K* is the carrying capacity (maximum level), *r* is the steepness of the curve and t_0 is the *x*-value of the sigmoid's midpoint. The function was named in 1844–1845 by Pierre François Verhulst, who studied it in relation to population growth. The initial stage of growth is approximately exponential; then, as saturation begins, the growth slows, and at maturity, growth stops. The logistic function finds applications in a range of fields, including agriculture.

For this fitting data process, only Treatment 3 (4000 kg/ha Bokashi/ha) is chosen because from result in Section 4.1 shows it is the highest plant among the treatments. From the parameter estimation procedure called 'fminsearch' in MATLAB, the best –fit parameters are:

$$K = 176.35$$

$$r = 0.60$$

$$t_0 = 8.12$$

From this model simulation, the calculated $R^2 = 0.9987$ using EXCEL function 'RSQ'. This shows that the model has a very good fit to the experimental data obtained.

Although, we only have the data of the height from week 1 until week 11, the model is able to predict the height of the plant until 14 weeks. It shows that the plant is still growing its height until it reached a maintain height at 176.35 cm which is approximately after week 14.

What can we say about this simulation is that, even if, Treatment 3 gives the highest plant, but that does not mean it will give the most yield of okra (as in result Section 4.7). All the energy of the plant in Treatment 3 goes to the growth of the height and number of flowers instead of yield.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The purposes of this study were to observe the growth pattern and yield of okra under different amount of Bokashi and to fit the experimental data growth of okra to the logistic curve equation. This study has found out that the value of independent variables have no significant different statistically between all the treatments. However, numerically, it was found that Bokashi fertilizer improved the vegetative growth of okra plants. This showed that Bokashi fertilizer gave more benefit to plant growth compared to control treatments.

In the other hand, the performance of Bokashi treatments along with the controls varied for generative growth. This study that found that application of compost fertilizer resulted more fruits and higher yield value than some dosages of Bokashi. T3 (4 000 kg of Bokashi/ha) remained superior in both vegetative and generative growth performance.

The findings suggest that the growth pattern and yield do differ physically and after the data was fit into the graph, it can be seen that some treatments performed well than others. The finding of this thesis could be used to help farmers of agro-entrepreneurs identified the best dosage of Bokashi and growth pattern okra plants under other dosages Bokashi and compost fertilizer. Lastly, further studies need to be carried out to analyse the poor performance of T5 (8 000 kg of Bokashi/ha).

5.2 RECOMMENDATION

As a recommendation based on the finding, the good result of Bokashi application with the dosage of 4 000kg/ha on okra plants can be practiced by farmers. As suggested by Bosch, Hitman and Hoekstra (2016), instead of traditional composting, farmers should switch to another farming method which was Bokashi fertilization as it caused lower organic matter loses and lower $C0_2$-footprint to the environment, thus help providing optimum nutrients for plants.

The amount of this Bokashi dosage is also lower than the common practice of 10 000 kg/ha compost. Reduced amount of fertilizer can reduce operation cost of a farm while increasing the profit by enhancing the productivity of okra plants. However, although the result from this study is promising, availability of the nutrients from the Bokashi product for okra growth after applying on the field need to be studied to gain more information.

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APPENDICES

Appendix A Plant Height Post Hoc Test Using Duncan

Between-Subjects Factors

		Value Label	N
Bokashi	1	0 kg/ha	3
	2	2000 kg/ha	3
	3	4000 kg/ha	3
	4	6000 kg/ha	3
	5	8000 kg/ha	3
	6	10 000 kg/ha	3

Tests of Between-Subjects Effects

Dependent Variable: Plant Height

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2083.236[a]	5	416.647	.550	.736
Intercept	111785.681	1	111785.681	147.650	.000
BKS	2083.236	5	416.647	.550	.736
Error	9085.208	12	757.101		
Total	122954.125	18			
Corrected Total	11168.444	17			

a. R Squared = .187 (Adjusted R Squared = -.152)

Plant Height

Duncan

Bokashi	N	Subset 1
0 kg/ha	3	63.417
10 000 kg/ha	3	70.833
8000 kg/ha	3	74.583
6000 kg/ha	3	79.083
2000 kg/ha	3	91.167
4000 kg/ha	3	93.750
Sig.		.244

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square (Error) = 757.101.

Appendix B Plant Leaves Post Hoc Test Using Duncan

Between-Subjects Factors

		Value Label	N
Bokashi	1	0 kg/ha	3
	2	2000 kg/ha	3
	3	4000 kg/ha	3
	4	6000 kg/ha	3
	5	8000 kg/ha	3
	6	10 000 kg/ha	3

Tests of Between-Subjects Effects

Dependent Variable: Plant Leaves

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	97.265[a]	5	19.453	.258	.928
Intercept	9295.661	1	9295.661	123.169	.000
BKS	97.265	5	19.453	.258	.928
Error	905.652	12	75.471		
Total	10298.578	18			
Corrected Total	1002.916	17			

a. R Squared = .097 (Adjusted R Squared = -.279)

Plant Leaves

Duncan

Bokashi	N	Subset
		1
0 kg/ha	3	19.08
10 000 kg/ha	3	20.92
6000 kg/ha	3	21.77
8000 kg/ha	3	24.00
2000 kg/ha	3	25.00
4000 kg/ha	3	25.58
Sig.		.421

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = 75.471.

Appendix C Plant Branches Post Hoc Test Using Duncan

Between-Subjects Factors

		Value Label	N
Bokashi	1	0 kg/ha	3
	2	2000 kg/ha	3
	3	4000 kg/ha	3
	4	6000 kg/ha	3
	5	8000 kg/ha	3
	6	10 000 kg/ha	3

Tests of Between-Subjects Effects

Dependent Variable: Plant Branches

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.986[a]	5	.597	.342	.878
Intercept	86.681	1	86.681	49.630	.000
BKS	2.986	5	.597	.342	.878
Error	20.958	12	1.747		
Total	110.625	18			
Corrected Total	23.944	17			

a. R Squared = .125 (Adjusted R Squared = -.240)

Plant Branches

Duncan

Bokashi	N	Subset
		1
0 kg/ha	3	1.58
8000 kg/ha	3	1.75
10 000 kg/ha	3	2.17
6000 kg/ha	3	2.42
4000 kg/ha	3	2.58
2000 kg/ha	3	2.67
Sig.		.379

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square (Error) = 1.747.

Appendix D Number of Flowers Post Hoc Test Using Duncan

Between-Subjects Factors

		Value Label	N
Bokashi	1	0 kg/ha	3
	2	2000 kg/ha	3
	3	4000 kg/ha	3
	4	6000 kg/ha	3
	5	8000 kg/ha	3
	6	10 000 kg/ha	3

Tests of Between-Subjects Effects

Dependent Variable: Number of Flowers

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8.042[a]	5	1.608	.358	.868
Intercept	288.000	1	288.000	64.049	.000
BKS	8.042	5	1.608	.358	.868
Error	53.958	12	4.497		
Total	350.000	18			
Corrected Total	62.000	17			

a. R Squared = .130 (Adjusted R Squared = -.233)

Number of Flowers

Duncan

Bokashi	N	Subset
		1
10 000 kg/ha	3	3.25
0 kg/ha	3	3.50
8000 kg/ha	3	3.50
2000 kg/ha	3	4.08
6000 kg/ha	3	4.50
4000 kg/ha	3	5.17
Sig.		.334

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square (Error) = 4.497.

Appendix E Total Fruit Post Hoc Test Using Duncan

Between-Subjects Factors

		Value Label	N
Bokashi	1	0 kg/ha	3
	2	2000 kg/ha	3
	3	4000 kg/ha	3
	4	6000 kg/ha	3
	5	8000 kg/ha	3
	6	10 000 kg/ha	3

Tests of Between-Subjects Effects

Dependent Variable:Number of Fruit

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	214.036[a]	5	42.807	.547	.738
Intercept	3781.601	1	3781.601	48.320	.000
BKS	214.036	5	42.807	.547	.738
Error	939.133	12	78.261		
Total	4934.770	18			
Corrected Total	1153.169	17			

a. R Squared = .186 (Adjusted R Squared = -.154)

Number of Fruit

Duncan

Bokashi	N	Subset 1
8000 kg/ha	3	9.20
0 kg/ha	3	11.37
2000 kg/ha	3	14.77
6000 kg/ha	3	15.53
10 000 kg/ha	3	16.17
4000 kg/ha	3	19.93
Sig.		.203

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square (Error) = 78.261.

Appendix F Yield per Pot Hoc Test Using Duncan

Between-Subjects Factors

		Value Label	N
Bokashi	1	0 kg/ha	3
	2	2000 kg/ha	3
	3	4000 kg/ha	3
	4	6000 kg/ha	3
	5	8000 kg/ha	3
	6	10 000 kg/ha	3

Tests of Between-Subjects Effects

Dependent Variable:Yield per Plot

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.744E6[a]	5	748787.822	.329	.886
Intercept	1.345E8	1	1.345E8	59.080	.000
BKS	3743939.111	5	748787.822	.329	.886
Error	2.731E7	12	2275882.056		
Total	1.655E8	18			
Corrected Total	3.105E7	17			

a. R Squared = .121 (Adjusted R Squared = -.246)

Yield per Plot

Duncan

Bokashi	N	Subset 1
8000 kg/ha	3	2.1070E3
0 kg/ha	3	2.1877E3
10 000 kg/ha	3	2.6437E3
2000 kg/ha	3	3.0457E3
6000 kg/ha	3	3.1687E3
4000 kg/ha	3	3.2460E3
Sig.		.417

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square (Error) = 2275882.056.

Appendix G Yield per Plant Hoc Test Using Duncan

Between-Subjects Factors

		Value Label	N
Bokashi	1	0 kg/ha	3
	2	2000 kg/ha	3
	3	4000 kg/ha	3
	4	6000 kg/ha	3
	5	8000 kg/ha	3
	6	10 000 kg/ha	3

Tests of Between-Subjects Effects

Dependent Variable:Yield per Plant

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	91220.763[a]	5	18244.153	.504	.768
Intercept	1791661.401	1	1791661.401	49.475	.000
BKS	91220.763	5	18244.153	.504	.768
Error	434562.107	12	36213.509		
Total	2317444.270	18			
Corrected Total	525782.869	17			

a. R Squared = .173 (Adjusted R Squared = -.171)

Yield per Plant

Duncan

Bokashi	N	Subset 1
8000 kg/ha	3	208.533
0 kg/ha	3	261.267
2000 kg/ha	3	297.133
6000 kg/ha	3	337.333
10 000 kg/ha	3	357.100
4000 kg/ha	3	431.600
Sig.		.218

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square (Error) = 36213.509.

Appendix H Okra Plots

Figure G.1 T1R3

Figure G.2 T6R3

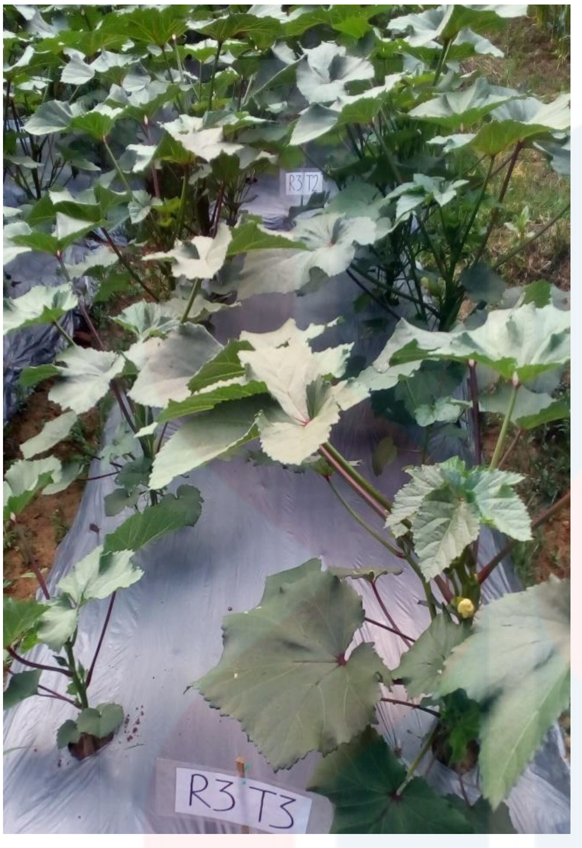

Figure G.3 T3R3