THE EFFECTS OF BANANA WASTE BIOCHAR ON SOIL MACRONUTRIENT AND GROWTH PERFORMANCE OF AEROBIC RICE

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DECLARATION

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IZZAINUR BINTI ISMAIL

ABSTRACT

EFFECTS OF BANANA WASTE BIOCHAR ON SOIL MACRONUTRIENT AND GROWTH PERFORMANCE OF AEROBIC RICE

Application of biochar is commonly reported to improve crop yield and enhance soil quality. This study was carried out to determine the effects of various banana waste biochar on soil macronutrient and the growth performance of aerobic rice. The experimental units were arranged in complete randomized design (CRD). It consists of five treatments and four replications. Aerobic rice seedlings were grown in soil treated with different types of biochar of the same amount which is 62.10 g /pot. The treatments are without biochar (T0), banana peel (BP) biochar (T1), banana leaves (BL) biochar (T2), 1:1 ratio of BP and BL (T3), and rice husk (RH) biochar (T4). All treatments received recommend NPK fertilizer of 0.414 g/pot. The banana peel and leaves was produced by pyrolysis process at 340 ^{o}C for four hours, while rice husk biochar was obtained from Sekinchan, Selangor. The results of pH reading of biochar for T1, T2, T3 and T4 is alkali range 7.50 to 8.54. The analytical result for plant height (cm) shows that the trend T1 and T4 increase start from week 4th until the week 9th. The number of tiller for T1 is increased at 4th week until 6th week and remained constant until 9th week. The number of leaves for T0 increased from 4th week until 7th week and then decreased at 9th week. The number of panicle for all treatments increased with time. Dry matter weight (g) of T3 is higher than compare to other treatments. Macronutrient content in soil shows that there is no significance difference among treatments. Among all treatments, T3 and T1 produced the highest filled grain weight 2.8 g compared to T0, T2, and T4.

Keywords : banana waste biochar, aerobic rice, growth performance, rice husk biochar

ABSTRAK

KESAN BIOCHAR DARI BAHAN BUANGAN PISANG KEPADA MAKRONUTRIEN TANAH DAN TUMBESARAN PADI AEROB

Penggunaan biochar kebiasaannya dilaporkan untuk meningkatkan hasil tanaman dan menambahbaikan kualiti tanah. Dalam kajian ini, untuk mengenalpasti kesan biochar dari pelbagai jenis bahan buangan pisang kepada komposisi tanah dan tumbesaran padi aerob. Eksperimen unit ini dijalankan dalam bentuk rawak lengkap (CRD). Ianya terdiri dari lima rawatan dan empat pengulangan. Benih padi aerob ditanam di tanah yang telah dirawat dengan pelbagai jenis biochar dengan nilai yang sama iaitu 62.10 g/bekas. Rawatan tanpa biochar (T0), biochar kulit pisang (T1), biochar daun pisang (T2), 1:1 *nisbah biochar kulit* pisang dan daun pisang (T3), dan biochar sekam padi (T4). Semua rawatan menerima baja NPK yang disarankan sebanyak 0.414 g/bekas. Biochar kulit pisang dan daun pisang dihasilkan dari proses pirolisis pada suhu 340 ^{o}C selama empat jam, sementara biochar sekam padi yang diperolehi dari Sekinchan, Selangor. Hasil bacaan pH biochar untuk rawatan T1, T2, T3 and T4 ialah alkali dalam lingkungan 7.50 hingga 8.54. Hasil analisis untuk ketinggian pokok (cm) menunjukkan corak T1 dan T4 meningkat bermula dari minggu keempat sehinnga minggu kesembilan. Bilangan batang untuk T1 meningkat pada minggu keempat sehingga minggu keenam dan kekal sehingga minggu kesembilan. Bilangan daun untuk T0 meningkat dari minggu keempat sehingga minggu ketujuh dan menurun pada minggu kesembilan. Bilangan tangkai buah untuk semua rawatan meningkat dengan masa. Berat kering (g) untuk T3 lebih tinggi berbanding rawatan yang lain. Kandungan makronutrien dalam tanah menunjukkan tiada perbezaan yang signifikan antara semua rawatan. Antara semua rawatan, T3 dan T1 menghasilkan berat bijirin penuh yang tinggi iaitu 2.8 g berbanding T0, T2, dan T4.

Kata kunci : biochar bahan buangan pisang, padi aerob, tumbesaran, biochar sekam padi

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LIST OF ABBREVIATIONS

CRD	Complete randomly design
MARDI	Mardi Agricultural Research Development Institute
EFB	Empty fruit bunch
N	Nitrogen
P	Phosphorus
K	Potassium
Ca	Calcium
Mg	Magnesium
CEC	Cation exchange capacity
HNO^3	Nitric acid
HCl	Hydrochloric acid
MgO	Magnesium oxide
Te	Trace element
NUE	Nitrogen use efficiency
DMW	Dry matter weight

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The total area of Malaysian is about 328 600 km^2 of which Peninsular Malaysia is 131 600 km^2, area of Sabah is 73700 km^2 and Sarawak is 123 300 km^2 (Mohd Hadi et al,. 2014). Malaysian Ministry of Agriculture has identified that banana is one of the 16 fruit types as having commercial potential either as fresh or processed fruit (Teo Chee How, 2002). In Malaysia, banana is the second most widely planted fruit that are covering about 26 000 ha with a total production is 530 000 metric tonnes. In Malaysia, banana was produced for it is commercial value for small farmers (Teo Chee, 2002). Banana is highly nutritious and (Pannaraphat Takolpuckdee, 2013) easily digestible other than many fruit including apple (Mohiuddin et al,. 2014).

Biochar is a charred by-product of biomass pyrolysis produced from biological wastes, crop residues, animal poultry manure or any type of organic waste materials (Kannan et al,. 2013) and at the same time to provide energy and increase crop yield (Xu Gang et al., 2012). Pyrolysis is where the substance is breakdown with high temperature in the condition without of an oxygen (Kannan et al,. 2013). The production of biochar was generally related with slow pyrolysis. In slow pyrolysis process, oxygen is absent and the range of duration time is from several to ten hours and relatively low temperatures. The raw materials used to produce biochar are banana peels, banana leaves and banana stem. In general, with increasing pyrolysis temperature from 300 to 800 ^{o}C, the carbon content also increased at the expenses of nitrogen (Xu Gang et al., 2012). The nutrient content also increased with increasing the temperature of biochar. Addition of biochar to the soil can enhanced organic matter content and also improved soil fertility in the soil (Xu Gang et al., 2012).

Biochar gives benefit in agriculture sector by protecting environment in reducing atmospheric carbon dioxide, provide sustainable economic opportunities for regional and rural industries, improve soil quality, remediate poor soil and increase agricultural productivity, deliver net biodiversity outcomes in the soil and above ground, give an opportunity for beneficial recycling of certain urban and industrial waste materials (Kannan et al,. 2013).

According to Rosenani (2014), application rice husk biochar changed some of the soil chemical properties, soil pH and CEC of the soil. The biochar made from rice husk has marginal alkaline properties and higher elemental Ca, Mg, and Na compare to rice husk ash (Agusalim, 2010). Biochar can be obtained either from durian peel, banana peel, mangosteen rind, corncob and shrimp shell to study the nutrient content in all this type of biochar (Pannraphat, 2013). The highest phosphorus content was found in banana peel biochar was 6.6338 ppm.

According to Essien in 2005 banana (*Musa Sapientum*) fruit peel is an organic waste that is highly rich in potassium content and other basic nutrients that could give nutrient to plant growth. The potential economic benefits which may use the banana peel as a nutrient for plant growth and to improve plant performance, soil quality and functioning (Maria et al,. 2008).

1.2 Problem Statement

Agricultural waste is one of the most affected on environmental management. The conversion of agricultural waste such as banana leaves, banana peel and durian peel to soil amendments is a very strategic and economically wise action. It is because the end product of these recyclable materials are very useful in improving soil quality and reducing environmental pollution. Agro-based industries face a major problem in disposal the management waste. In banana plantation prior harvest, there are a lot of banana wastes from stem, leaves and peel. The potential of banana waste biochar is seen to overcome this problem. Biochar can reduces soil compaction, improves soil physical condition and enhances nutrient uptake from the soil.

1.3 Research Questions

i. Is there an effects between the differences of various type of banana waste biochar with the soil properties?
ii. Is there any effect between the soil properties and the growth of aerobic rice?

1.4 Research Objectives

i. To determine the effect of the various type of biochar to nutrient content in soil properties.

ii. To determine the nutrients content in soil properties after biochar application that can affect the growth performance of aerobic rice.

1.5 Significance of the Study

This study is important to determine which one of various type of banana waste biochar that will improve soil properties and help in growth of aerobic rice. This study also to provide a better practices to farmer to manage their agricultural waste products at same time it can give more benefits as a soil amendments.

1.6 Definition of Terms

The term in this study need to be defined as well as to give an understanding to people especially to the researcher. There are:

1.6.1 Biochar: Biochar is the carbon-rich product that produced when waste biomass is pyrolysis in a closed container with restricted air conditions.

1.6.2 Soil properties: Properties can be defined as a composition and proportion that are include the texture, structure and porosity.

1.6.3 Aerobic rice: Aerobic rice is a production system where rice is grown in well-drained, non-puddled and non-saturated soils (Parthasarathi et al, 2012).

CHAPTER 2

LITERATURE REVIEW

2.1 Aerobic rice

It is a different approach of rice cultivation where a high yielding rice is grown in non-puddled and non-saturated fields with supplementary irrigation (Chan et al, 2012). Aerobic rice is a production system where rice is grown well-drained. To cultivate aerobic rice must have better yield performance of low land condition and better drought performance of upland condition with desired root traits. There are two potential aerobic rice varieties namely SAE 1 and AERON 1 that are tested in MARDI Kota Kinabalu for two seasons (Helda Shouki and Sariam Othman).

2.2 Banana waste biochar

Biochar or biological charcoal defined as the product of biomass pyrolysis, the process of burning at high temperature (Hamdan et al,. 2011). Biomass product such as stalks, straw, wood and leaves and it added to soil to improve fertility and plant growth (Hariz et al,. 2015). The previous research, empty fruit bunch (EFB) was pyrolysed under different pyrolysis temperature and the biochar product obtained was characterized (Azri et al,. 2011).

Table 2.2 : properties of biochar product at different temperature with heating rate of 30 ^{0}C/min and particle size of 91-106 μm.

	Temperature (^{0}C)				
Properties	300	400	500	600	700
Carbon (%)	59.62	65.94	65.32	67.87	68.63
Hydrogen (%)	4.02	4.42	4.56	4.04	2.71
Oxygen (%)	34.05	25.73	28.69	25.27	27.45
Nitrogen (%)	2.31	3.91	1.43	2.82	1.21

Based on above table the highest hydrogen and nitrogen content obtained was 4.56 and 3.91 respectively at final pyrolysis temperature of 500 °C and 400 °C respectively (Azri et al,. 2011). Increasing the surface area of a substances, will increase the rate of a chemical reaction. At high temperature was detrimental to the development of a porous structure in the biochar (Azri et al,. 2011).

2.2.1 Effects of biochar on crop performance and plant nutrient uptake

Previously research, biochar amendments have been shown to increase crop productivity by improving the physical and biochemical properties of soil with variation in crop response that depend on the chemical and physical properties of the biochar, soil condition and type of crop (Hamdan et al,. 2011).

2.2.2 Effects of biochar on soil chemical properties

Biochar, according to Hamdan (2005) can retain high amounts of fertilizer-derived nutrients due to its high pororsity and surface ratio. Biochar soil amendment increase pH of acidic soil, improve nutrient uptake by plants, increase availability of macronutrient such as phosphorus (P), potassium (K) and Calcium (Ca). The increase cation exchange capacity (CEC) and oxygen, carbon ratio which enhanced biochar capacity to retain nutrients (Hamdan et al,. 2005).

2.3 Soil properties

Biochar benefits to the soil properties by increased CEC, biological activity, water and air circling in the soil. The porosity can increase gradually if biochar contains high concentration of ash which eventually will leach from the pores.

CHAPTER 3

MATERIALS AND METHOD

3.1 Location of study

This field experiment was been conducted at the greenhouse of UiTM Jasin Campus from February to May, 2015. It took about 72 days after emergence to mature.

Figure 3.1.1 Arrangements of pots in greenhouse

3.2 Experimental procedure

3.2.1 Planting Material

In this experiment, aerobic rice variety MRIA1 was used as the planting materials. The seeds obtained from a farmer in Merlimau, Melaka. The seeds were sown in a tray in order to choose the best seedling. After 14 days, the selected seedlings were transferred to the pots containing 4 kg soil.

Figure 3.2.1.1 The seedling in a tray for one week

3.2.2 Laboratory-generated banana waste biochar

The banana wastes such as peel and leaves were charred through a slow pyrolysis. Banana wastes were cut freshly and placed in a lid covered crucible then pyrolysis in a muffle furnace at 340 ^{o}C for four hours. The biochar was grounded using a pestle and mortar and sieve to size ≥ 100 microns. The biochar was kept in zip-locked plastic bags to reduce moisture content in soil samples (Appendix B).

3.2.3 Treatment preparation

The amount of banana waste biochar applied to each treatment was 62.10 g/pot. The various types of banana waste biochar were peel (T1), leaves (T2), combination peel and leaves (T3) and rice husk biochar (T4) was mixed into the soil before transplanting the paddy seedlings into the pot. A recommended amount of chemical fertilizer NPK (16:15:15) + MgO + Te + NUE and urea were applied in T0 for control treatment.

Amount of banana waste biochar per pot (g/pot)

$$\text{Organic fertilizer, (g)} = \frac{\text{Area vase } (m^2) \times \text{Organic fertilizer (kg/ha)}}{10000\ m^2} \times 1000\ g$$

Amount of banana waste biochar per pot (g/pot)

Treatment 0 (T0) = 100% recommended fertilizer 120:60:60 kg/ha

NPK (16:15:15) + MgO + Te + NUE (nitrogen use efficiency)

$$\textbf{Stage 1} = \frac{200\ kg/ha \times 0.0207\ m^2 \times 1000\ g}{10{,}000\ m^2} = 0.414\ g/pot$$

Urea

$$\textbf{Stage 2} = \frac{80\ kg/ha \times 0.0207\ m^2 \times 1000\ g}{10{,}000\ m^2} = 0.1656\ g/pot$$

NPK (16:15:15) + MgO + Te + NUE

$$\textbf{Stage 3} = \frac{200\ kg/ha \times 0.0207\ m^2 \times 1000\ g}{10{,}000\ m^2} = 0.414\ g/pot$$

Urea

$$\textbf{Stage 4} = \frac{40\ kg/ha \times 0.0207\ m^2 \times 1000\ g}{10{,}000\ m^2} = 0.0828\ g\ /pot$$

T1 (banana peel biochar), T2 (banana leaves biochar), T3 (combination of banana peel and leaves biochar), T4 (rice husk biochar)

T1, T2, T3, T4 = 15 t/ha banana peel biochar

$$= \frac{\left[\frac{18\ cm \times 23\ cm}{10{,}000}\right] \times 15{,}000\ kg/ha \times 1000\ g}{10{,}000\ m^2}$$

$$= 62.10\ g/pot$$

3.2.4 Experimental design

The experimental units were arranged in completely randomized design (CRD) with five treatments of four replications as shown in Figure 3.2.4.1.

Table 3.2.4.1 Arrangement of 20 experimental units in CRD

T0R1	T1R2	T2R3	T3R4
T1R1	T2R2	T3R3	T4R4
T2R1	T3R2	T4R3	T0R4
T3R1	T4R2	T0R3	T1R4
T4R1	T0R2	T1R3	T2R4

Table 3.2.4.2 The treatment was applied and the rate of each treatment

Treatment	**Rate of Treatment (g/pot)**
T0 (control)	Recommended NPK Fertilizer and Urea
T1	62.10 g of banana peel biochar
T2	62.10 g of banana leaves biochar
T3	62.10 g combination banana peel and leaves biochar
T4	62.10 g of paddy husk biochar

*Note: 1 pot contains 4 kg of soil.

3.3 Soil analysis

3.3.1 Soil pH

To determine soil pH, a ratio of soil sample to deionized water (1:10) was placed in a 100 ml conical flask. The sample stirred using an orbital shaker for 15 minutes at 180 rpm. The pH reading was taken 24 hours after shaking by using a pH meter (Mettler Toledo)

3.3.2 Total nutrients (P, K, Ca, Mg)

Soil sample was air-dried for 48 hours before it was grounded by using a pestle and mortar. Then, soil were sieved to 200μm. Soil sample of 10 g was placed in a 100 ml conical flask. Ten ml of distilled water, 10 ml of concentrated nitric acid, (HNO_3) and 10 ml of hydrochloric acid (HCl) were poured into the conical flask. The samples were heated at 200 ^{o}C using a hot plate until vaporization stopped. The samples were cooled at room temperature. Then it were filtered using a filter paper (Whatman Cat No 1002 090). The solution was marked up to 50 ml water. The P, K, Ca and Mg concentration in the solution sample was measured using Inductively Coupled Plasma Optima 7300 DV (ICP-OES) (Appendix C).

3.3.3 Biochar pH

Preparation for soil pH, a 5 g of biochar samples were added to conical flask together with 50 ml of deionized water. The samples were stirred for 15 minutes using an orbital shaker for 15 minutes at 180 rpm. The pH reading was taken 24 hours after shaking by using a pH meter (Mettler Toledo).

3.4 Growth of paddy analysis

The growth performance of aerobic rice variety MRIA 1 from the fourth week until the ninth week was recorded. The parameters are plant height, number of leaves, number of tiller and the number of panicle. The height of plant was measured from on the soil surface to a tip of leaves.

3.5 Data analysis

Data was subjected analysis of variance (ANOVA) at 5% level of significance by using Minitab software version 16.

CHAPTER 4

RESULTS

4.1 Characteristic of soil origin and biochar

Soil origin and Biochar	pH	N(%)	P(%)	K(%)	Ca(%)
Soil origin	4.76				
Banana peel	8.54				
Banana leaves	8.40	**1.05	**0.16	**8.68	**1.83
Banana peel and leave	8.51				
Rice husk	7.50	*0.32	*0.07	*0.12	*0.27

Source 1: *Agusalim (2010), ** Kajsa Alvum-Toll (2011)

The pH of biochar was differ between 4 and 12, mainly depending on the feedstock and pyrolysis conditions (Lehmann, 2011). The increase in temperature pyrolysis, the increase of biochar pH. Applying biochar to soil generally increases soil pH, especially in low pH soils.

4.2 Plant height

Table 4.2 Plant height (cm) response to biochar application in nine weeks.

Treatment	Weeks after transplanting						
	4	5	6	7	8	9	P-value
T0 (NPK)	54.50^{b}	76.50^{b}	109.00^{a}	119.75^{a}	130.25^{a}	128.25^{a}	0.000
T1 (62.10g BP)	55.50^{d}	82.00^{c}	115.50^{b}	130.25^{a}	132.75^{a}	133.00^{a}	0.000
T2 (62.10g BL)	50.75^{a}	69.25^{a}	98.50^{a}	107.25^{a}	98.00^{a}	97.75^{a}	0.417
T3 (31.05g BP+BL)	50.00^{b}	76.00^{ab}	98.50^{a}	111.00^{a}	116.75^{a}	116.50^{a}	0.001
T4 (62.10g RH)	56.25^{b}	64.75^{b}	107.25^{a}	121.50^{a}	129.25^{a}	129.50^{a}	0.000

Note: Mean value within row are information using Turkey's Method by different letter(s) are not significantly different at 5% level. Data expressed as means value of 4 replication. *BP = banana peel, BL = banana leaves, BP+BP = combination banana peel and banana leaves, RH = rice husk.

The analytical results in Table 4.2 shows that the trend of plant height for T1 and T4 increase with time start from week 4^{th} until the 9^{th} week. At week 9, no significant difference among treatments at p-value = 0.527. T0 and T4 increase from week 4^{th} until the 8^{th} week. The plant height for T2 stop increase at 7^{th} week and start to decline until 9^{th} week.

4.3 Number of tiller

Table 4.3 Number of tiller response to biochar application in nine weeks.

Treatment	Weeks after transplanting						
	4	5	6	7	8	9	P-value
T0 (NPK)	3^b	4^{ab}	6^{ab}	7^a	7^a	7^a	0.010
T1 (62.10g BP)	3^b	4^{ab}	8^a	8^a	8^a	8^a	0.000
T2 (62.10g BL)	2^a	5^a	6^a	6^a	5^a	5^a	0.873
T3 (31.05g BP+BL)	2^a	4^a	6^a	6^a	5^a	6^a	0.454
T4 (62.10g RH)	3^b	6^a	8^a	7^a	7^a	7^a	0.000

Note: Mean value within row are information using Turkey's Method by different letter(s) are not significantly different at 5% level. Data expressed as means value of 4 replication. *BP = banana peel, BL = banana leaves, BP+BL = combination banana peel and banana leaves, RH = rice husk.

The analytical results presented in Table 4.4 shows that the trend number of tiller for T1 and T4 increased at 4th week until 6th week. While there was no significant difference in T0, T2 and T3 throughout the planting period. At week 9, no significant difference among treatments at p-value = 0.580.

4.4 Number of leaves

Table 4.4 Number of leaves response to biochar application in nine weeks

Treatment	Weeks after transplanting						
	4	5	6	7	8	9	P-value
T0 (NPK)	12^{b}	18^{ab}	24^{ab}	27^{a}	27^{a}	21^{ab}	0.021
T1 (62.10g BP)	11^{b}	18^{ab}	32^{a}	32^{a}	31^{a}	21^{ab}	0.000
T2 (62.10g BL)	9^{a}	19^{a}	23^{a}	23^{a}	22^{a}	16^{a}	0.959
T3 (31.05g BP+BL)	6^{a}.	15^{a}	23^{a}	23^{a}	23^{a}	16^{a}	0.504
T4 (62.10g RH)	10^{b}	24^{a}	32^{a}	31^{a}	31^{a}	20^{a}	0.000

Note: Mean value within row are information using Turkey's Method by different letter(s) are not significantly different at 5% level. Data expressed as means value of 4 replication. *BP = banana peel, BL = banana leaves, BP+BL = combination banana peel and banana leaves, RH = rice husk.

The analytical results presented in Table 4.3 shows that the trend number of leaves T0 and T4 start increase from 4^{th} week until 7^{th} week and it start to decrease at 9^{th} week. At the week 9, no significant difference among treatments at p-value = 0.618. Number of leaves of T1 and T4 in the 4^{th} week was significant lower than the later weeks.

4.5 Number of panicle

Table 4.5 Number of panicle response to biochar application in nine weeks

Treatment	Weeks after transplanting 8	9	P-value
T0 (NPK)	4.00[a]	5.00[a]	0.000
T1 (62.10g BP)	4.00[a]	5.00[a]	0.000
T2 (62.10g BL)	4.00[a]	4.00[a]	0.001
T3 (31.05g BP+BL)	3.00[a]	4.00[a]	0.001
T4 (62.10g RH)	4.00[a]	6.00[a]	0.000

Note: Mean value within row are information using Turkey's Method by different letter(s) are not significantly different at 5% level. Data expressed as means value of 4 replication. *BP = banana peel, BL = banana leaves, BP+BL = combination banana peel and banana leaves, RH = rice husk.

The analytical results presented in table 4.5 shows that the trend number of panicle is increase with the increase in time. At week 9, showed there was no significant difference among treatments at p-value = 0.793.

4.6 Dry Matter Weight

Table 4.6 Dry matter weight (g)

Treatment	Mean
T0 (NPK)	15.30^{a}
T1 (62.10g BP)	17.00^{a}
T2 (62.10g BL)	11.00^{a}
T3 (31.05g BP+BL)	17.55^{a}
T4 (62.10g RH)	13.95^{a}

Note: Mean value within row are information using Turkey's Method by different letter(s) are not significantly different at 5% level. Data expressed as means value of 4 replication. *BP = banana peel, BL = banana leaves, BP+BL = combination banana peel and banana leaves, RH = rice husk.

The analytical results presented in table 4.6 shows that the dry weight of aerobic rice on the 9th week, no significant difference among treatments at p-value = 0.652. The application of banana peel biochar and combination of banana peel and leaves biochar increased the total dry matter weight (DMW) than the control (without biochar).

4.7 Weight of 100 filled grains (g) at 72 days after sowing

Table 4.7 Weight of 100 filled grains (g) at 72 days after sowing

Treatment	weight 100 grains (g)
T0 (NPK)	2.8
T1 (62.10g BP)	2.8
T2 (62.10g BL)	2.6
T3 (31.05g BP+BL)	2.8
T4 (62.10g RH)	2.6

*BP = banana peel, BL = banana leaves, BP+BL = combination banana peel and banana leaves, RH = rice husk.

4.8 Macronutrient content response to biochar application in nine weeks

Table 4.8 Macronutrient content response to biochar application in nine weeks.

Total soil nutrient (mg/kg)	Treatment					
	T0 (NPK)	T1 (62.10g bp)	T2 (62.10g bl)	T3 (31.05g bp+bl)	T4 (62.10g rh)	P-value
Phosphorus	61.54[a]	67.67[a]	68.78[a]	72.05[a]	54.58[a]	0.942
Potassium	586.60[a]	346.50[a]	712.50[a]	854.80[a]	496.70[a]	0.796
Calcium	1145.00[a]	743.00[a]	962.20[a]	823.60[a]	616.00[a]	0.592
Magnesium	109.60[a]	97.59[a]	113.40[a]	102.05[a]	104.12[a]	0.982

Mean in the same column are not significantly different at 5% level of significance. *BP = banana peel, BL = banana leaves, BP+BL= combination banana peel and banana leaves, RH = rice husk.

The analytical results presented in table 4.8 shows that the all macronutrient content in soil there was no significant difference among treatments at p-value > 0.005.

4.9 Soil pH response to biochar application in nine weeks

Table 4.9 Soil pH response to biochar application in nine weeks.

Treatment	pH
T0 (NPK)	5.89^{a}
T1 (62.10g BP)	5.44^{a}
T2 (62.10g BL)	6.40^{a}
T3 (31.05g BP+BL)	6.53^{a}
T4 (62.10g RH)	6.41^{a}

Mean in the same column are not significantly different at 5% level of significance. *BP = banana peel, BL = banana leaves, BP+BL = combination banana peel and banana leaves, RH = rice husk.

The analytical results presented in table 4.9 shows that the pH meter is increases after applied with various type of biochar. Treatment 2 is the highest pH more to alkali pH meter 7 compare to other treatment.

CHAPTER 5

DISCUSSION

The results from field trials with various type of biochar conducted at greenhouse showed that plant height among treatment is same. At week 9, there was no significant difference among treatments on plant height. This could be due to the variation in crop response that depend on the chemical and physical properties of the biochar, soil properties and type of crop (Hamdan and Shamshuddin 2011).

In this research, a parameter number of tiller shows that there was no significant difference among treatments in week 9. The result from this study reveal that the response number of tiller aerobic rice to biochar application varied between different types of biochar (Varela et al,. 2013). According to Pramod, (2010) the production of biochar and its application to the soil will deliver immediate benefit through improved soil fertility and increase crop production.

The number of panicle at week 9, showed there was no significant difference among treatments. According to Yoseftabar, (2013) the numbers of panicle are associated with the tiller production which is most important yield attributing character. The characteristics of rice husk biochar contains 0.32% Nitrogen (Agusalim, 2010) and it can increase rice grain yield.

According to the result of the present study, total amount of macronutrient in soil there was no significant difference among treatments. This could be due to the soil condition that was used in this research. Total amount of phosphorus and potassium in soil determine the nutrient uptake by plant.

The statistical analysis revealed a significant increase in pH due to addition of the various type biochar. Banana peel biochar, banana leaves biochar, combination of banana peel and leaves biochar and rice husk biochar had a high pH (Table 4.1), therefore it is reasonable that the soil treated with all treatment also had a high pH. This result indicated that rice husk biochar (Table 4.9) could be used as a substitution for lime materials to increase the pH of acidic soils (Agusalim, 2010).

CHAPTER 6

CONCLUSION AND RECOMMENDATION

A research study was conducted to identify which one from various types of biochar have effects to soil properties and the growth performance of aerobic rice. The experimental results of banana waste biochar and rice husk biochar as soil amendment applications significantly improve soil properties in increasing soil pH, soil organic matter and total P, exchangeable K, exchangeable Ca and exchangeable Mg.

The improvement of soil properties with organic soil amendments applications resulted in an improvement of paddy aerobic growth as shown by an increases in plant height, number of tiller, number of leaves, number of panicle and dry matter biomass.

Moreover, banana peel and banana leaves are not discovered for biochar production. There was some production biochar that was already have in market such as empty fruit bunches, rice husk biochar, coconut shell biochar, wood biochar. Therefore, in future study, I recommended that other to should look into the nutrient content in banana peel, banana leaves and also nutrient availability for plant growth.

In addition, Abebe (2012) revealed that addition of biochar increased the availability nutrient for plant uptake. The application of biochar is important in order to increase soil fertility, enhance nutrient uptake and hold availability nutrient for plant. The previous research was studied the characteristics of rice husk and wood biochar (Varela et al,. 2013). According to Hariz, (2015) the conventional production of biochar in Malaysia has been famous. Rice husk biochar and coconut shell biochar are two types of biochar that was widely produced and used in agricultural sector.

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APPENDICES

Appendix A

One-way ANOVA: Plant height (cm) week 9 versus Treatment

Source	DF	SS	MS	F	P
Treatment	4	3319	830	0.83	0.527
Error	15	15020	1001		
Total	19	18338			

One-way ANOVA: Plant height (cm) T0 versus Week

Source	DF	SS	MS	F	P
Week	5	19005	3801	34.00	0.000
Error	18	2012	112		
Total	23	21017			

One-way ANOVA: Plant height (cm) T1 versus Week

Source	DF	SS	MS	F	P
Week	5	20883.8	4176.8	122.15	0.000
Error	18	615.5	34.2		
Total	23	21499.3			

One-way ANOVA: Plant height (cm) T2 versus Week

Source	DF	SS	MS	F	P
Week	5	9632	1926	1.05	0.417
Error	18	32898	1828		
Total	23	42530			

One-way ANOVA: Plant height (cm) T3 versus Week

Source	DF	SS	MS	F	P
Week	5	14357	2871	7.68	0.001
Error	18	6727	374		
Total	23	21084			

One-way ANOVA: Plant height (cm) T4 versus Week

Source	DF	SS	MS	F	P
Week	5	21461	4292	40.41	0.000
Error	18	1912	106		
Total	23	23373			

One-way ANOVA: Number of tiller week 9 versus Treatment

Source	DF	SS	MS	F	P
Treatment	4	1.328	0.332	0.74	0.580
Error	15	6.745	0.450		
Total	19	8.073			

One-way ANOVA: Number of tiller T0 versus week

Source	DF	SS	MS	F	P
week	5	2.650	0.530	4.24	0.010
Error	18	2.249	0.125		
Total	23	4.899			

One-way ANOVA: Number of tiller T1 versus week

Source	DF	SS	MS	F	P
week	5	5.0829	1.0166	10.49	0.000
Error	18	1.7449	0.0969		
Total	23	6.8278			

One-way ANOVA: Number of tiller T2 versus week

Source	DF	SS	MS	F	P
week	5	1.512	0.302	0.35	0.873
Error	18	15.398	0.855		
Total	23	16.910			

One-way ANOVA: Number of tiller T3 versus week

Source	DF	SS	MS	F	P
week	5	4.154	0.831	0.99	0.454
Error	18	15.180	0.843		
Total	23	19.334			

One-way ANOVA: Number of tiller T4 versus week

Source	DF	SS	MS	F	P
week	5	3.6813	0.7363	14.25	0.000
Error	18	0.9299	0.0517		
Total	23	4.6112			

One-way ANOVA: Number of leaves week 9 versus Treatment

Source	DF	SS	MS	F	P
Treatment	4	2.201	0.550	0.68	0.618
Error	15	12.174	0.812		
Total	19	14.376			

One-way ANOVA: Number of leaves T0 versus week

Source	DF	SS	MS	F	P
week	5	2.088	0.418	3.55	0.021
Error	18	2.114	0.117		
Total	23	4.202			

One-way ANOVA: Number of leaves T1 versus week

Source	DF	SS	MS	F	P
week	5	4.518	0.904	7.93	0.000
Error	18	2.050	0.114		
Total	23	6.569			

One-way ANOVA: Number of leaves T2 versus week

Source	DF	SS	MS	F	P
week	5	1.50	0.30	0.20	0.959
Error	18	27.14	1.51		
Total	23	28.64			

One-way ANOVA: Number of leaves T3 versus week

Source	DF	SS	MS	F	P
week	5	4.169	0.834	0.90	0.504
Error	18	16.733	0.930		
Total	23	20.903			

One-way ANOVA: Number of leaves T4 versus week

Source	DF	SS	MS	F	P
week	5	3.7909	0.7582	15.41	0.000
Error	18	0.8857	0.0492		
Total	23	4.6767			

One-way ANOVA: Number of panicle week 9 versus Treatment

Source	DF	SS	MS	F	P
Treatment	4	0.574	0.143	0.42	0.793
Error	15	5.145	0.343		
Total	19	5.718			

One-way ANOVA: Number of panicle T0 versus week

Source	DF	SS	MS	F	P
week	5	10.2450	2.0490	35.83	0.000
Error	18	1.0293	0.0572		
Total	23	11.2743			

One-way ANOVA: Number of panicle T1 versus week

Source	DF	SS	MS	F	P
week	5	10.1885	2.0377	55.45	0.000
Error	18	0.6615	0.0368		
Total	23	10.8500			

One-way ANOVA: Number of panicle T2 versus week

Source	DF	SS	MS	F	P
week	5	7.767	1.553	6.50	0.001
Error	18	4.301	0.239		
Total	23	12.067			

One-way ANOVA: Number of panicle T3 versus week

Source	DF	SS	MS	F	P
week	5	7.137	1.427	6.49	0.001
Error	18	3.960	0.220		
Total	23	11.097			

One-way ANOVA: Number of panicle T4 versus week

Source	DF	SS	MS	F	P
week	5	11.9639	2.3928	66.32	0.000
Error	18	0.6494	0.0361		
Total	23	12.6133			

One-way ANOVA: Phosphorus versus Treatment

Source	DF	SS	MS	F	P
Treatment	4	767	192	0.19	0.942
Error	15	15387	1026		
Total	19	16154			

One-way ANOVA: Potassium versus Treatment

Source	DF	SS	MS	F	P
Treatment	4	610812	152703	0.41	0.796
Error	15	5530002	368667		
Total	19	6140814			

One-way ANOVA: Calcium versus Treatment

Source	DF	SS	MS	F	P
Treatment	4	664722	166181	0.72	0.592
Error	15	3462541	230836		
Total	19	4127264			

One-way ANOVA: Magnesium versus Treatment

Source	DF	SS	MS	F	P
Treatment	4	622	155	0.10	0.982
Error	15	24241	1616		
Total	19	24863			

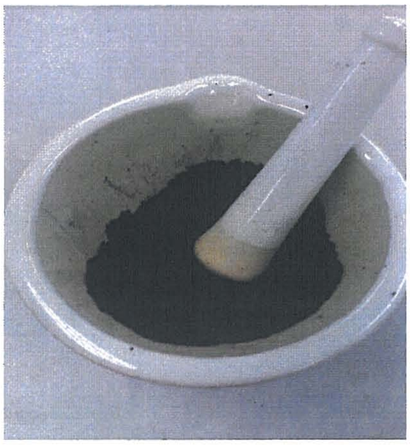
One-way ANOVA: pH versus Treatment

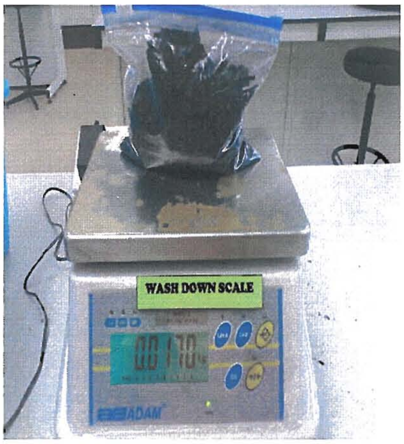
Source	DF	SS	MS	F	P
treatment 1	4	1.671	0.418	1.23	0.405
Error	5	1.703	0.341		
Total	9	3.374			

One-way ANOVA: Dry weight versus Treatment

Source	DF	SS	MS	F	P
Treatment	4	110.7	27.7	0.62	0.652
Error	15	665.3	44.4		
Total	19	776.0			

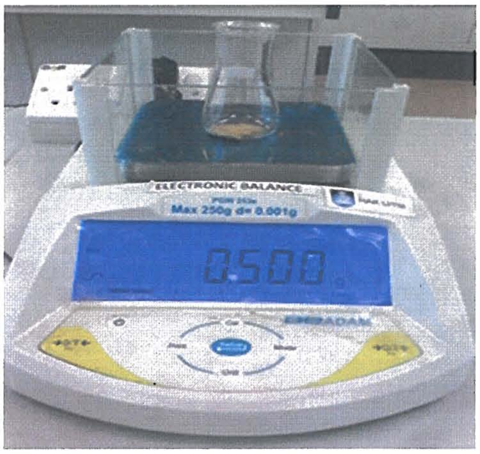
Appendix B

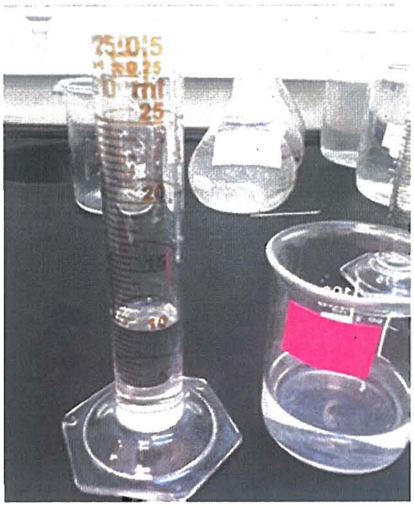


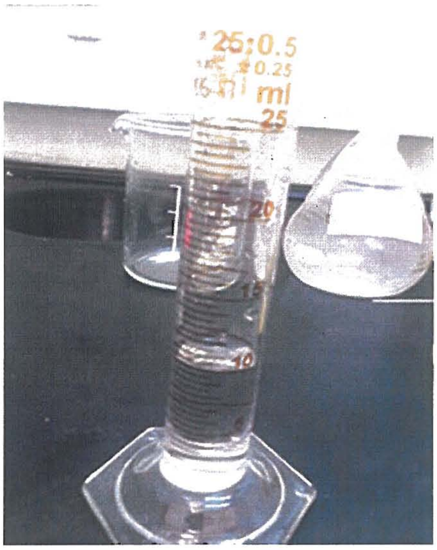


Preparation of biochar application to soil

Appendix C



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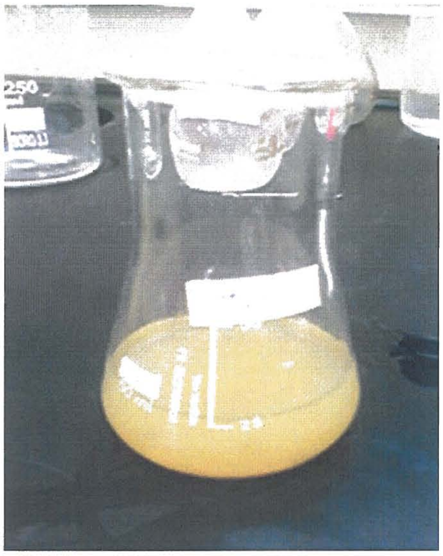
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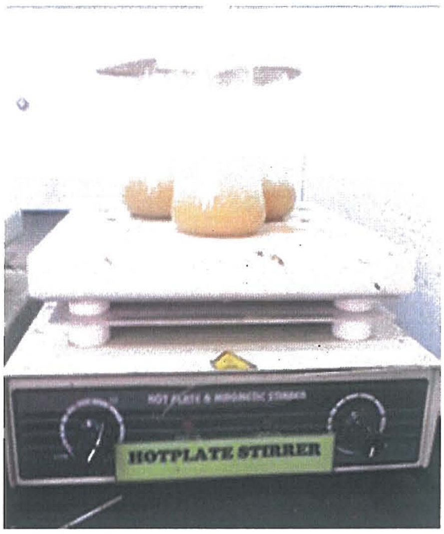
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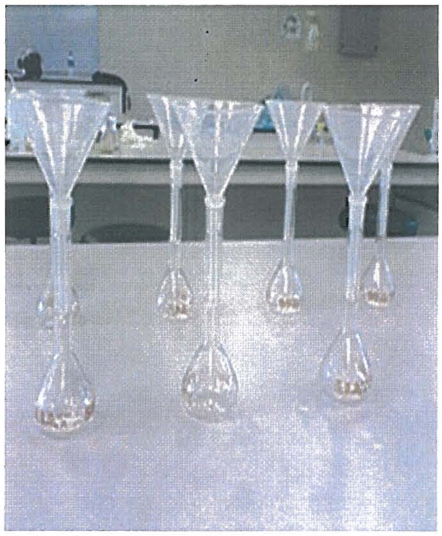

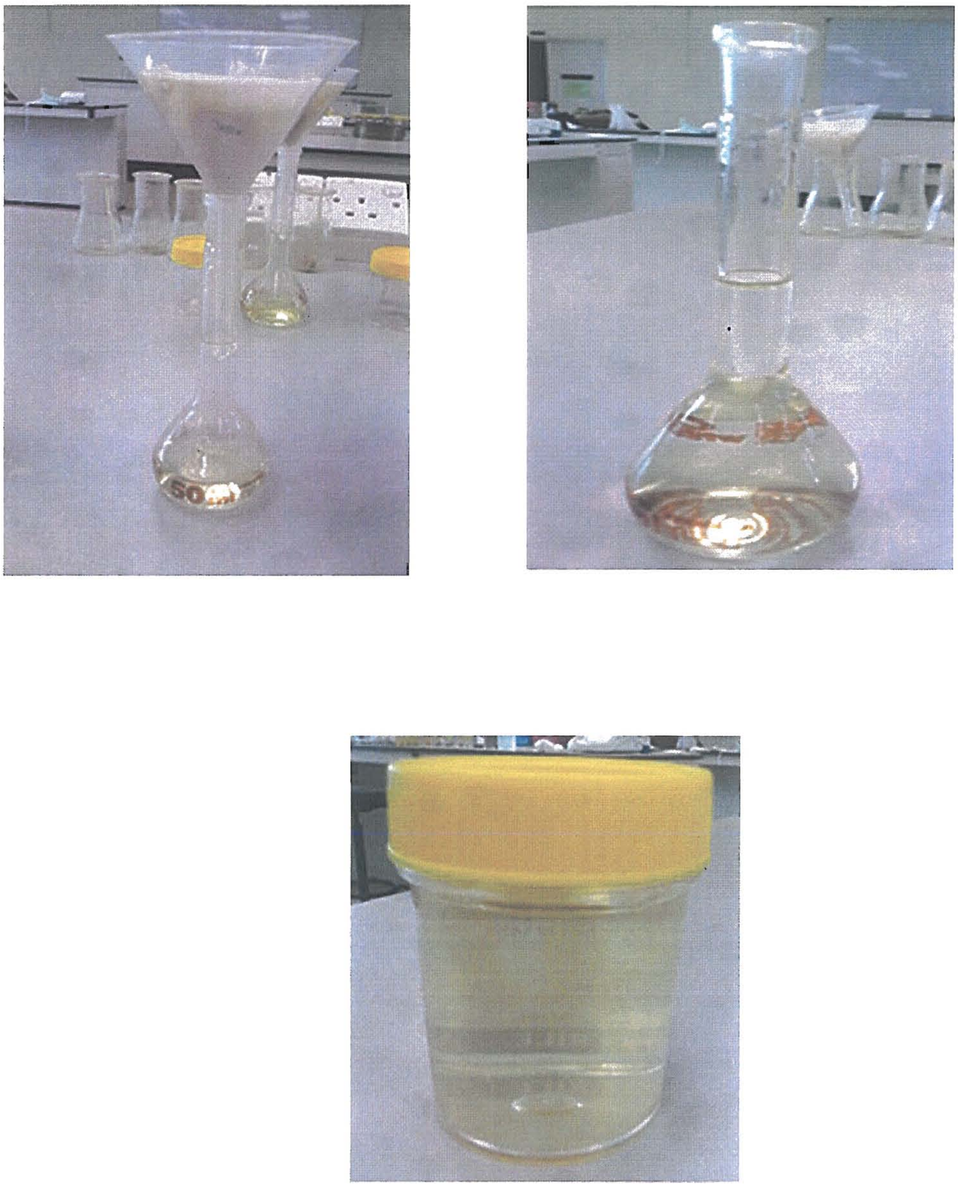

Preparation for total amount nutrient (P, K, Ca, Mg)

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Signature : .... Date : 30. 07. 2015..........................