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RESEARCH ARTICLE

EFFECTS OF BOTTOM ASH AND COW MANURE COMPOST ON CHEMICAL PROPERTIES OF SOIL AT NEW-ESTABLISHED RICE FIELD

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ABSTRACT

The conversion of dryland to rice field at Sumatra Island, Indonesia was generally developed on marginal lands with Ultisols and Oxisols soil types. Those soil types contained high iron (Fe) and aluminum (Al), but low phosphorus (P) and potassium (K). That is because the changes in the process resulted from submerging the soil. For example, the decrease of redox potential, ion reduction from Fe^{3+} to Fe^{2+}, and Mn^{4+} into Mn^{2+}. Those compounds will be dissolved and can be absorbed by plants thus causing toxicity. The objective of the study was to assess the effects of bottom ash and cow manure compost at the various doses on soil chemical properties and rice yield on the new-established rice field. This research used factorial design with two factors in Completely Randomized Design. The factors were a dose of bottom ash and cow manure compost, with three replications. The results showed. The addition of bottom ash and cow manure compost at the dosage in this study was not able to reduce the levels of FeDTPA and MnDTPA at newly established rice fields. However, the application of cow manure compost significantly increased soil pH, exchangeable cation (K, Na, Ca), base saturation and decreased exchangeable-H. The addition of bottom ash does not affect paddy yield, while cow manure compost up to 10 tons ha^{-1} increased panicle and straw dry weight.

Keywords: new-established rice field, bottom ash, cow manure compost, chemical properties

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INTRODUCTION

Food demand, especially rice, will continue to increase in line with the increase of population, so the Indonesian government is trying to increase rice production. One of the opportunities that will contribute substantially to future rice production growth is the opening of new paddy fields. The development of paddy fields of new openings from drylands at Sumatra island is generally on marginal lands with Ultisols and Oxisols, which contained high levels of Fe and Al with P and K deficiencies. (Hartatik et al., 2010) stated that rice crops were grown in new openings in Lampung, South Sumatra, Jambi, Riau, West Sumatra and Bengkulu generally have Fe toxicity.

The problems of the new opening lands were the changes in chemical properties as a result of flooding, such as: (1) the decrease of redox potential and (2) the reduction of Fe^{3+} into Fe^{2+} and Mn^{4+} into Mn^{2+} which are dissolved and can be absorbed by plants causing toxic (Nursyamsi et al., 1996).

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The Fe-toxic soil at new-established rice field leads to low production or even crop failure. According to (Hartatik et al., 2010) changes in soil chemical properties on marginal lands that are newly planted into potential paddy fields in Indonesia generally take up to 5 years, depending on the level of irrigation, soil iron content, and land management by farmers. Without proper management, the new opening will be stable after 10-15 years.

The new-established rice field in Sitiung, Dharmasraya Regency with Ultisol soil type was classified as infertile soil, which are characterized base saturation 15.46% (very low) Cation Exchangeable Capacity 15.20 me/100g (low), Organic Carbon 1.99% (low) and available P 4.63 ppm (low), Al saturation 49.89% (high) , Fe extract with 1 M CH_3COONa pH 2,8 57.32 ppm (very high), and likely to cause iron toxicity (Herviyanty et al., 2011). In addition, there was a change of redox potential become very low or negative, that will affect pH, Fe and another nutrients availability (Hartatik et al., 2010). To solve this problem, the action to repair soil condition, called the amelioration is important to support the optimal growth of rice.

Coal ash, which is in the form of a fly and bottom ash is very potential to be used as ameliorant because its availability is quite a lot as waste. According to Sell et al. (1989) the bottom ash was useful for ameliorant without adverse effects on soil, plants, and environment. Agustini (2016) adds that the bottom ash on acid minerals did not cause the heavy metals adsorption in choy sum (*Brassica juncea*) to rise or higher than the threshold. According to Park et al. (2012) bottom ash contains macronutrients (P, K, Ca, Mg, S) and microelements (Fe, Mn, Zn, Cu) which can be used for plant growth. This was supported by James et al. (2012) that the bottom ash has the potential to be a fixer and plant growth medium for fertilizing and neutralizing soil acidity.

Based on Iskandar at al. (2008) the addition bottom ash can increase the soil pH and the availability of base cations in peat soils. Agustini (2016) showed that bottom ash increased the pH, total N, available P and exchangeable cations (K, Na, Ca and Mg), increase crop growth and yield, also the N, P, K, Ca, Mg contents in choy sum. Cow manure compost can improve soil physical, chemical, and biological properties. Tan (1998) stated that the addition of organic material on soils containing excessive and dissolved Fe and Mn elements will form complexes. Utami & Handayani (2003) stated the presence of organic compounds allows the occurrence of chelate by binding the metal cations such as Fe and Mn. This is to reduce the binding of phosphate by Fe/Al oxide and silicate clay so that P becomes available.

The addition of bottom ash and cow manure compost is expected to overcome the problems in a new-established rice field, especially the chemical properties. The purpose of this research is to study the effects of bottom ash and cow manure compost at various doses on soil chemical properties and rice yield at new-established rice field.

MATERIALS AND METHODS

The materials used in this study were the coal bottom ash obtained from the landfill of Paiton power plant, cow manure compost, rice seed, and soil samples of Oxisols taken from Gunung Sindur, Bogor. The chemical properties of Oxisols soil for rice planting media are presented in Table 1.

A pot experiment was conducted in a greenhouse using Completely Randomized Design (CRD) with two factors and three replications. The first factor was a dose of bottom ash (0, 1, 2.5, and 5 tons ha^{-1}), while the second factor was a dose of cow manure. The chemical characteristics of the bottom ash and cow manure compost are presented in Table 3 and 4. Each experiment was repeated three times so that overall there were 36 experimental pots. The treatments for experiments in greenhouses are presented in Table 2.

Oxisols soil material weighing 8 kg of air dry put into a bucket and given water and stirred evenly using wood with the purpose of lubrication for 10 days, stirring is done repeatedly so that the soil really has a condition similar to paddy soil. Furthermore, ameliorant materials are mixed with the growing media until homogeneous and then incubated for 7 days. Ready-to-plant rice seedlings were selected in a homogeneous manner by seeing the height and number of leaves, then the seedlings were transplanted on media, three plants for each pot. After that, the drainage begins at intervals of 1 week, with a height of 3 cm of water from the ground and then drained. Next, fertilization, weeding, controlling plant pests, harvesting organisms and watering were conducted.

Table 1. Initial soil chemical properties (Oxisols)

Parameter	**Unit**	**Value**	**Determination Method/Measuring Device**
pH	-	4.01	pH meter
Organic-C	%	2.7	Walkley & Black
Total-P	mg P_2O_5 $100^{-1}g^{-1}$	33.2	Extracted with HCl
Available-P	ppm	1.0	Bray 1
Fe-dithionite	%	0.87	Extract Dithionite-citrate
Fe-oxalate	%	0.58	Extract Ammonium Oxalate 0,2 M pH 3
Fe_{DTPA}	ppm	58.3	Extract DTPA
Mn_{DTPA}	ppm	372	Extract DTPA
Exchangeable-Al	cmol(+) kg^{-1}	1.2	KCl 1 N
Exchangeable-H	cmol(+) kg^{-1}	0.3	KCl 1 N
CEC	cmol(+) kg^{-1}	18.4	Extracted with NH_4OAC 1 N pH 7
Exchangeable-Ca	cmol(+) kg^{-1}	1.4	Extracted with NH_4OAC 1 N pH 7
Exchangeable-Mg	cmol(+) kg^{-1}	0.4	Extracted with NH_4OAC 1 N pH 7
Exchangeable-Na	cmol(+) kg^{-1}	0.1	Extracted with NH_4OAC 1 N pH 7
Exchangeable-K	cmol(+) kg^{-1}	0.3	Extracted with NH_4OAC 1 N pH 7
Base saturation	%	11.9	-

Table 2. Combination of doses of bottom ash (A) and cow manure compost (K)

Treatment	**Doses of bottom ash (gram pot^{-1})**	**Doses of cow manure compost (gram pot^{-1})**
A0K0	0	0
A0K1	0	20
A0K2	0	40
A1K0	4	0
A1K1	4	20
A1K2	4	40
A2K0	10	0
A2K1	10	20
A2K2	10	40
A3K0	20	0
A3K1	20	20
A3K2	20	40

Table 3. Chemical characteristics of the bottom ash *)

Parameter	Unit	Value
pH H_2O	-	6.60
SiO_2	%	57.8
Al_2O_3	%	13.79
Fe_2O_3	%	16.93
K_2O	%	1.38
Na_2O	%	0.26
CaO	%	4.83
MgO	%	2.43
TiO_2	%	1.03
MnO	%	0.10
P_2O_5	%	0.026

*) Source : Agustini (2016)

Table 4. Characteristics of cow manure compost *)

Parameter	Method	Value
Water contect (%)	Gravimetri	23.74
C-total (%)	CNS-Analyzer	12.80
N-total (%)	CNS-Analyzer	1.53
C/N ratio	-	8
P_2O_5-total (%)	HNO_3/ *Spectrophotometer*	0.78
K_2O total (%)	HNO_3/ FAAS	1.13
Exchangeable -K(cmol(+) kg^{-1})	NH_4OAc pH 7	16.31
Exchangeable -Na (cmol(+) kg^{-1})	NH_4OAc pH 7	5.21
Exchangeable -Ca (cmol(+) kg^{-1})	NH_4OAc pH 7	19.66
Exchangeable -Mg (cmol(+) kg^{-1})	NH_4OAc pH 7	9.14

*) Source : Agustini (2016)

The soil properties observed during plant growth were redox potential (Eh) and pH (pH-meter), Fe and Mn contents in water, Fe_{DTPA}, and Mn_{DTPA} in the soil. After harvest, soil pH (pH-meter), exchangeable-H (KCl 1 M), CEC (NH_4OAc 1 N pH 7), exchangeable-Ca, -Mg, -K,-Na (NH_4OAc 1 N pH 7 extraction, K and Ca measured using flame photometer, Ca and Mg measured using ASS), Fe and Mn (DTPA extraction, measured using ASS) were observed. Crop growth and yield parameters observed were the numbers, length, and weight of panicles; pithy rice and dry straw weight. The data were analyzed using Analysis of Variance (ANOVA) and further testing using Duncan's Multiple Range Test (DMRT) at 5% significance level.

RESULTS

The Fluctuation of Soil Eh and pH, exchangeable-Fe and -Mn in water solution, Fe_{DTPA}, and Mn_{DTPA} during plant growth

The redox potential (Eh) is the soil chemical properties first changed by flooding. The effect of the dose of coal bottom ash and cow manure compost to soil Eh during plant growth is presented in Figure 1. It can be seen that Eh decreased at all treatments from the first to the 10th week, but then increased until the 16th week. However, the effects between treatments cannot be identified, either higher or lower. Eh decreased because during inundation the entire pore space was filled with water, so that the oxygen availability decreased and reduction process occurred. The increase at the 10th to 16th weeks was due to the plants have entered the generative phase and flooding was reduced, hence oxygen becomes more available.

The effects of bottom ash dose and cow manure compost on soil pH during rice plant growth is presented in Figure 2. It can be seen that soil pH all treatments increased from 1st to 16th week but insignificant. At 4th week, soil pH decreased due to the drainage termination, which was also shown by a relatively high increase of soil Eh. Generally soil Eh decreased (Figure 1) but soil pH increased during the growth (Figure 2). The increase in pH occurs because the reduction reaction is more dominant in consuming protons, as seen from the decrease in soil Eh during inundation.

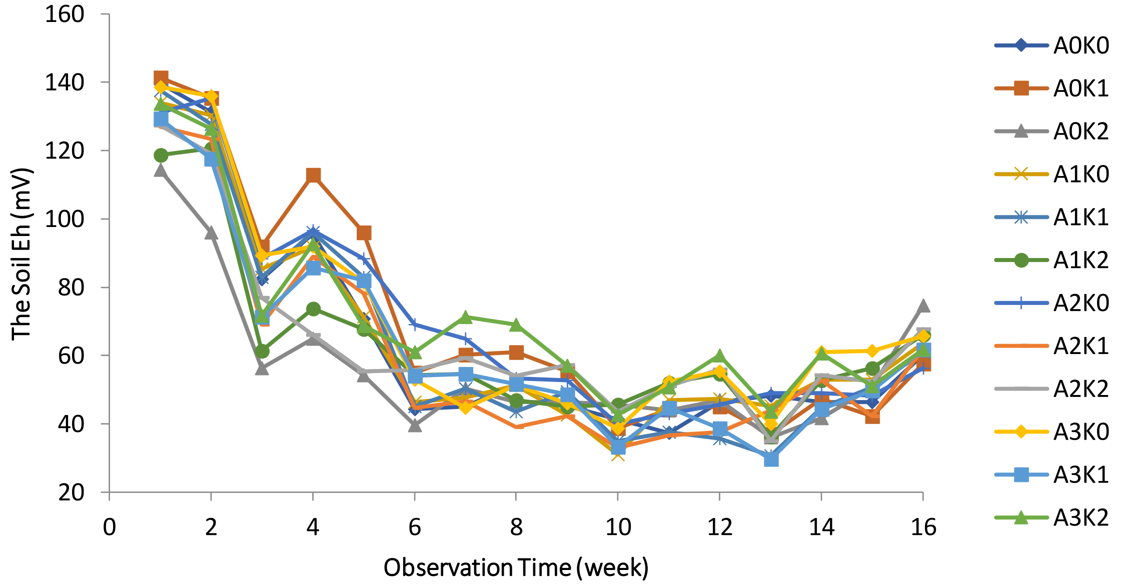

Figure 1. Effects of bottom ash dose and cow manure compost on soil Eh. A0: bottom ash 0 tons ha^{-1}, A1: bottom ash 1 ton ha^{-1}, A2: bottom ash 2.5 tons ha^{-1}, A3: bottom ash 5 tons ha^{-1}, K0: cow manure compost 0 tons ha^{-1}, K1: cow manure compost 5 tons ha^{-1}, K2: cow manure compost 10 tons ha^{-1}.

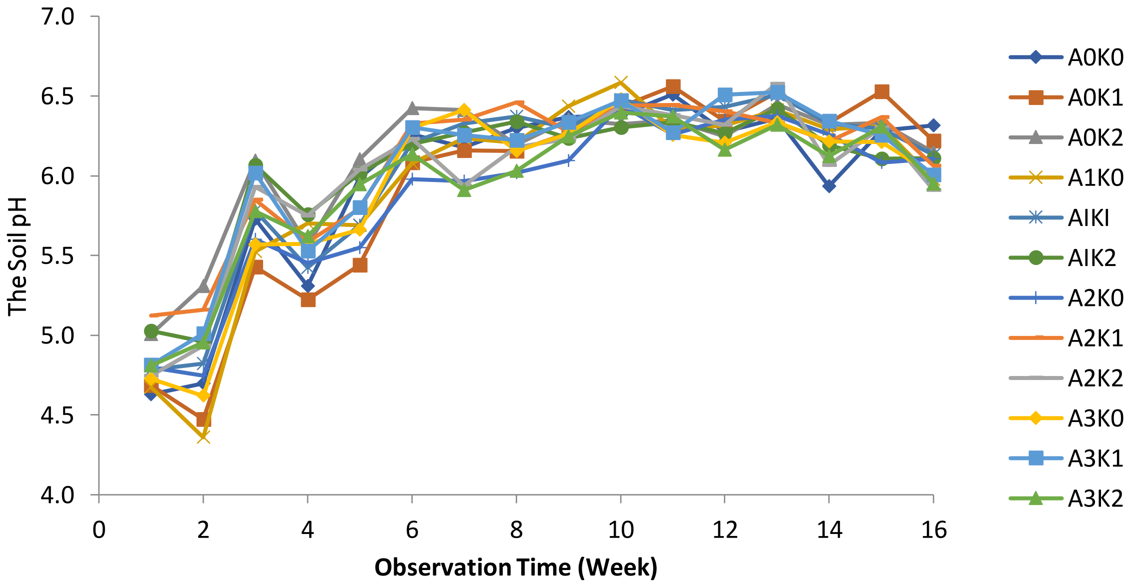

Figure 2. Effects of dose of bottom ash and cow manure compost on soil pH. A0: bottom ash 0 tons ha^{-1}, A1: bottom ash 1 ton ha^{-1}, A2: bottom ash 2.5 tons ha^{-1}, A3: bottom ash 5 tons ha^{-1}, K0: cow manure compost 0 tons ha^{-1}, K1: cow manure compost 5 tons ha^{-1}, K2: cow manure compost 10 tons ha^{-1}.

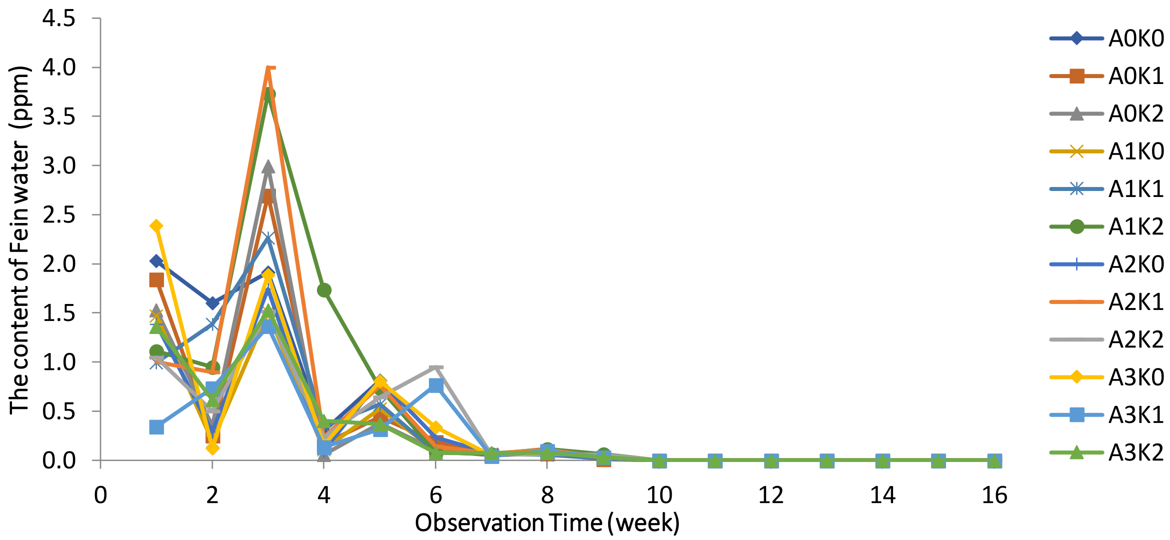

Figure 3. Effects of bottom ash dose and cow manure compost on the content of Fe in the drainage water. A0: bottom ash 0 tons ha^{-1}, A1: bottom ash 1 ton ha^{-1}, A2: bottom ash 2.5 tons ha^{-1}, A3: bottom ash 5 tons ha^{-1}, K0: cow manure compost 0 tons ha^{-1}, K1: cow manure compost 5 tons ha^{-1}, K2: cow manure compost 10 tons ha^{-1}

The effects of a dose of the bottom and cow manure compost on the content of Fe in drainage water during rice growth is presented in Figure 3. It can be seen that the content of content Fe in drainage water decrease related to the intermittent drainage, whereas Fe increased when submerged and decreased when drained. After 3 weeks, the Fe content in water was relatively stable. Water Fe was not measured again at 10th week, but however, the effects of treatments on water Fe has not been seen until the 16th week. The decrease in water Fe content related to the loss of the elements during a water change.

The effects of bottom ash dose and cow manure compost on the content of Mn in drainage water during rice growth is presented in Figure 4. It was found that the highest Mn content in water was 69.4 ppm, which increased from the 1st to 2nd week. Then decreased until the 16th week with the highest Mn concentration was only 4.2 ppm at the period, allegedly because of some element loss during a water change. However, the effect of each treatment has not been seen yet.

Fe and Mn contents in the drainage water decreased during submerging, which were thought due to the dilution effect. New inundated water contains more oxygen and thus the reaction was more oxidative, or at least, the formation of Fe^{2+} and Mn^{2+} can be suppressed. It also appears that Fe and Mn contents in the drainage water were smaller than in the soil (Figure 3 and 4).

The effects of bottom ash dose and cow manure compost on Fe_{DTPA} content in the soil during rice plant growth is presented in Figure 5. It was seen the mean Fe_{DTPA} content increased from 58.28 to 60 ppm in the first week of flooding, but dropped to 55.15 ppm at the 4th week. That is closely related to inundation and drying process. The Fe content still fluctuated up to 16th. Inundation reduced Fe^{3+} to Fe^{2+} which dissolves easily, and vice versa during drainage. However, the effect of each treatment has not been seen yet. The Content Fe_{DTPA} have not been seen to increase in the first week of submerging (Figure 5). The highest Fe_{DTPA} content was 102 ppm occurred at week 7th to 16th, with the average 63.25 ppm.

The effects of bottom ash dose and cow manure compost on Mn_{DTPA} content in the soil during plant growth is presented in Figure 6. It showed an increase in Mn_{DTPA} content in soil from the first week (472 ppm) to week 8th to reach 923 ppm. There was a decrease after that but until the 16th week it was unstable, ranged from 690 - 858 ppm. Mn_{DTPA} of soil is higher than Fe_{DTPA} (Figure 5 and 6), because similarly with the initial condition of the soil (Table 1). In contrast, Mn_{DTPA} content highly increased after submergence. The initial Mn_{DTPA} content was 372 ppm, increased up to 594 ppm (mean) in the 1st week, and reached the highest content at the 8th week (923 ppm), presented in Figure 6.

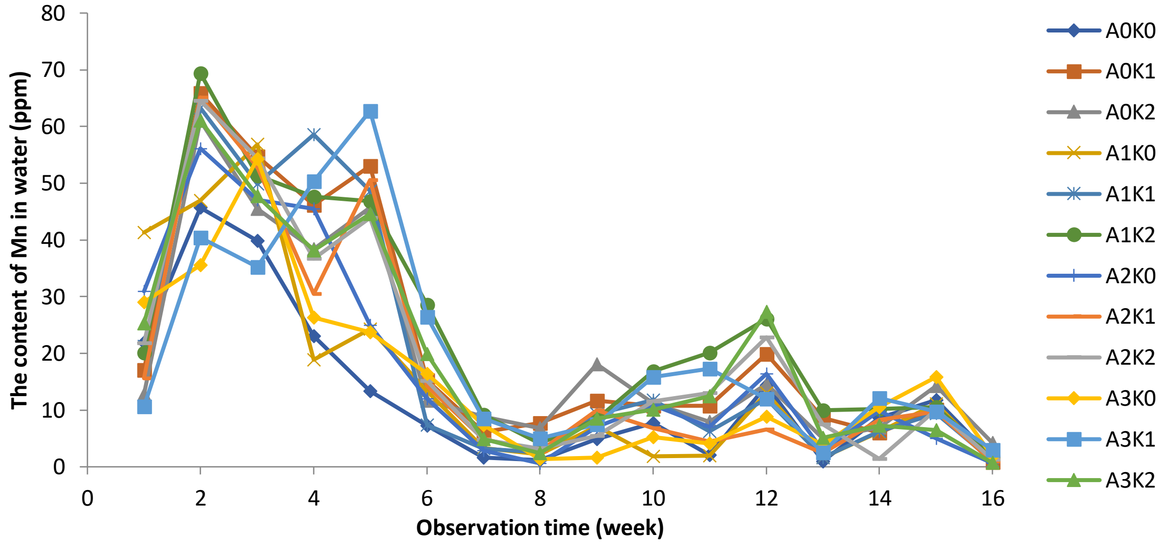

Figure 4. Effects of bottom ash dose and cow manure compost on the content of Mn in drainage water. A0: bottom ash 0 tons ha^{-1}, A1: bottom ash 1 ton ha^{-1}, A2: bottom ash 2.5 tons ha^{-1}, A3: bottom ash 5 tons ha^{-1}, K0: cow manure compost 0 tons ha^{-1}, K1: cow manure compost 5 tons ha^{-1}, K2: cow manure compost 10 tons ha^{-1}

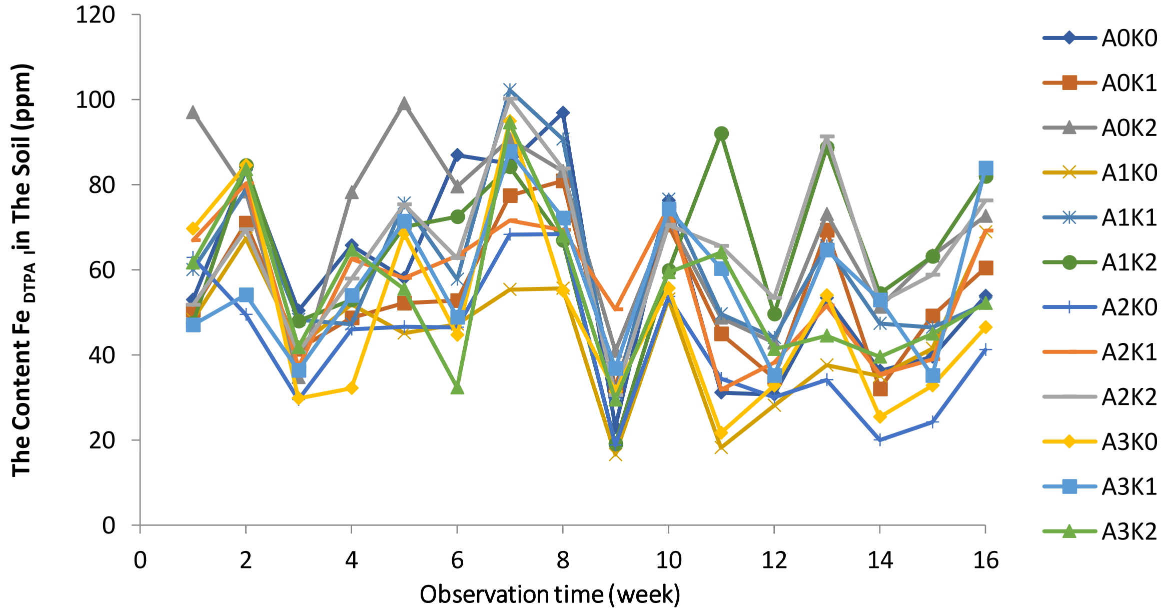

Figure 5. Effects of bottom ash dose and cow manure compost on the content Fe_{DTPA} in the soil. A0: bottom ash 0 tons ha^{-1}, A1: bottom ash 1 ton ha^{-1}, A2: bottom ash 2.5 tons ha^{-1}, A3: bottom ash 5 tons ha^{-1}, K0: cow manure compost 0 tons ha^{-1}, K1: cow manure compost 5 tons ha^{-1}, K2: cow manure compost 10 tons ha^{-1}

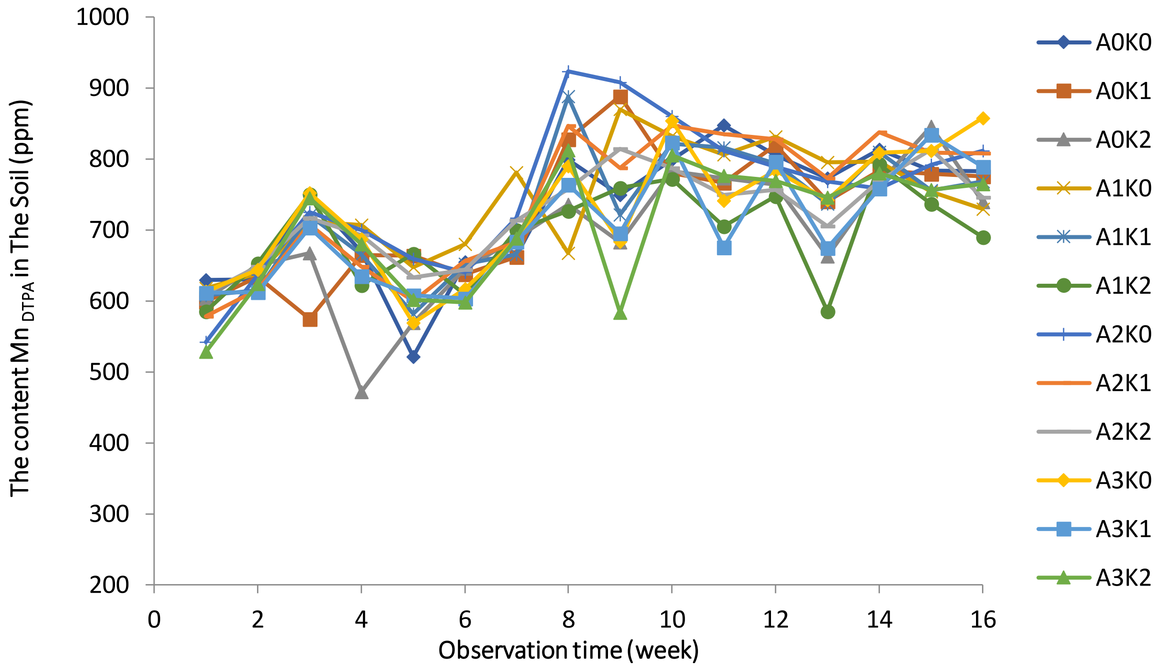

Figure 6. Effects of bottom ash dose and cow manure compost on The content Mn_{DTPA} in the soil. A0: bottom ash 0 tons ha^{-1}, A1: bottom ash 1 ton ha^{-1}, A2: bottom ash 2.5 tons ha^{-1}, A3: bottom ash 5 tons ha^{-1}, K0: cow manure compost 0 tons ha^{-1}, K1: cow manure compost 5 tons ha^{-1}, K2: cow manure compost 10 tons ha^{-1}

The effects of bottom ash dose and cow manure compost on Mn_{DTPA} content in the soil during plant growth is presented in Figure 6. It showed an increase in Mn_{DTPA} content in soil from the first week (472 ppm) to week 8th to reach 923 ppm. There was a decrease after that but until the 16th week it was unstable, ranged from 690 - 858 ppm. The initial Mn_{DTPA} content was 372 ppm, increased up to 594 ppm (mean) in the 1st week, and reached the highest content at the 8th week (923 ppm), presented in Figure 6. Fe_{DTPA} and Mn_{DTPA} in soil fluctuated at all weeks (Figure 5 and 6).

The Effects of Bottom Ash and Cow Manure Compost on Soil Chemical Properties

The effects of bottom ash dose and cow manure compost on soil pH, CEC, exchangeable-H, $Fe_{DTPA,}$ and Mn_{DTPA} are presented in Table 5. Table 5 shows bottom ash dose did not significantly increase soil pH, while cow manure compost dose significantly decreased soil pH but insignificantly improved soil CEC. Bottom ash dose insignificantly decreased exchangeable-H, whereas cow manure significantly decreased soil exchangeable-H. The addition of bottom ash and cow manure compost did not significantly reduce Fe_{DTPA} and Mn_{DTPA}. However, the Fe_{DTPA} and Mn_{DTPA} tended to decrease with the addition of a dose of bottom ash and cow manure compost. The application of cow manure compost as the organic material can reduce Fe and thus produces organic acids. The effects of bottom ash and cow manure compost on the exchangeable cations is presented in Table 6.

It is shown that the application of bottom insignificantly increased the exchangeable cations, but cow manure compost significantly increased exchangeable cations and all base saturation except exchangeable-Mg. The highest increase of exchangeable-Ca was under cow manure compost of 5 and 10 tons ha^{-1}, which were 0.11 and 0.24 cmol(+) kg^{-1}, respectively. Meanwhile, base saturation increased by 0.7 and 1.7 % under the same treatments, respectively. The addition of cow manure compost has been shown to increase the soil pH, exchangeable cation (K, Na, Ca), base saturation and decrease the soil exchangeable-H after harvest (Table 5 and 6).

The Effects of Bottom Ash and Cow Manure Compost on Yield

The effects of bottom ash dose and cow manure compost on rice yields, including panicle number, length, and weight; pithy rice and dry straw weight are presented in Table 7. It appears that the bottom ash insignificantly affected all yield's parameters, but the cow manure compost did. The increase of panicles number, length, and weight, pithy rice weight were in line with the increase of cow manure compost dosage, except straw dry weight. The application of 5 and 10 tons ha^{-1} cow manure compost increased panicle weight 3.19 and 12.37 g pot^{-1}, and straw dry weight 15.86 and 13.58 g pot^{-1}, respectively.

Table 5. Effects of Bottom Ash Dose and Cow Manure Compost on Soil pH, CEC, Exchangeable-H, Fe_{DTPA}, and Mn_{DTPA}

Treatment	pH (H_2O)	CEC	Exchangeable-H	Fe_{DTPA}	Mn_{DTPA}
		-------------(cmol(+)kg^{-1})-------------		--------- (ppm)----------	
The dose of bottom ash					
A0	4.51 a	17.09 a	0.23 a	170 a	700 a
A1	4.51 a	17.73 a	0.27 a	188 a	666 a
A2	4.52 a	17.67 a	0.28 a	140 a	673 a
A3	4.53 a	17.09 a	0.27 a	144 a	668 a
The dose of cow manure compost					
K0	4.57 a	17.17 a	0.32 a	172 a	672 a
K1	4.52 b	17.51 a	0.27 ab	168 a	676 a
K2	4.45 c	17.54 a	0.19 b	141 a	683 a

Remarks: Mean with different letter are significantly different at $P < 0.05$ using a DMRT test. A0: bottom ash 0 tons ha^{-1}, A1: bottom ash 1 ton ha^{-1}, A2: bottom ash 2.5 tons ha^{-1}, A3: bottom ash 5 tons ha^{-1}, K0: cow manure compost 0 tons ha^{-1}, K1: cow manure compost 5 tons ha^{-1}, K2: cow manure compost 10 tons ha^{-1}

Table 6. Effects of Bottom Ash Dose and Cow Manure Compost on Exchangeable Cations and Base Saturation

Treatment	Exchangeable -K	Exchangeable -Na	Exchangeable -Ca	Exchangeable -Mg	Base saturation
	------------------------(cmol(+)kg^{-1})--------------------------				(%)
The dose of bottom ash					
A0	0.26 a	0.15 a	1.75 a	0.39 a	14.97 a
A1	0.26 a	0.15 a	1.88 a	0.40 a	15.15 a
A2	0.25 a	0.13 a	1.84 a	0.43 a	15.11 a
A3	0.25 a	0.14 a	1.74 a	0.40 a	14.81 a
The dose of cow manure compost					
K0	0.23 a	0.13 a	1.69 a	0.39 a	14.24 a
K1	0.27 b	0.14 ab	1.80 ab	0.40 a	14.94 ab
K2	0.27 b	0.16 b	1.93 b	0.43 a	15.94 b

Remarks: Mean with different letter are significantly different at $P < 0.05$ using a DMRT test. A0: bottom ash 0 tons ha^{-1}, A1: bottom ash 1 ton ha^{-1}, A2: bottom ash 2.5 tons ha^{-1}, A3: bottom ash 5 tons ha^{-1}, K0: cow manure compost 0 tons ha^{-1}, K1: cow manure compost 5 tons ha^{-1}, K2: cow manure compost 10 tons ha^{-1}

Table 7. Effects of Bottom Ash Dose and Cow Manure Compost on Rice Yield

Treatment	Panicle number (strands)	Panicle length (cm)	Panicle weight (grams)	Pithy rice weight (grams)	Dry straw weight (grams)
The dose of bottom ash					
A0	9.33 a	18.52 a	9.32 a	5.40 a	19.07 a
A1	9.56 a	18.77 a	10.73 a	6.60 a	18.36 a
A2	8.67 a	19.12 a	10.19 a	6.30 a	17.50 a
A3	9.67 a	18.38 a	9.00 a	5.00 a	16.10 a
The dose of cow manure compost					
K0	6.75 a	17.36 a	4.63 a	2.40 a	11.27 a
K1	9.08 b	18.24 a	7.82 a	4.57 a	27.13 b
K2	12.08 c	20.49 b	17.00 b	10.50 b	24.85 c

Remarks: Mean with different letter are significantly different at $P < 0.05$ using a DMRT test. A0: bottom ash 0 tons ha^{-1}, A1: bottom ash 1 ton ha^{-1}, A2: bottom ash 2.5 tons ha^{-1}, A3: bottom ash 5 tons ha^{-1}, K0: cow manure compost 0 tons ha^{-1}, K1: cow manure compost 5 tons ha^{-1}, K2: cow manure compost 10 tons ha^{-1}

DISCUSSION

The addition of bottom ash and cow manure compost on the new-established paddy field generally decreased soil Fe_{DTPA} and Mn_{DTPA} (Table 5) but not significant, because these two elements are strongly influenced by soil pH. This was supported by Cyio (2008) which states that changes in soil Eh and pH are affected by nutrients solubility and availability, as well as their transformation. According to the Eh-pH diagram (Krauskopf, 1979), the Mn content in this study would continue to dissolve during inundation because it is not stable compared to Fe. However, the Mn_{DTPA} of soil is higher than Fe_{DTPA} because similarly with the initial condition of the soil (Table 1). Redman & Patrick Jr. (1965) reported that after flooding for 30 days and the addition of Mn, the mobilization of organic matter increased sharply from 159.4 to 1,730 ppm. Hassett & Banwart (1992) state that Mn was an unstable element under an oxidation-reduction condition in the soil solution. Millaleo et al. (2010) added that the bioavailability of soil Mn was influenced by pH and redox potential. Furthermore, Porter et al. (2004) reported that changes in soil pH and redox potential (Eh) will affect the Mn solubility and toxicity for plants on soils with high Mn.

Changes in soil redox potential and pH affect the active Fe in the soil solution. Based on the diagram shown by Bohn & O'connor (1979), FeOOH will dissolve into Fe^{2+} at a specific Eh and pH under moderate acidity conditions, while Fe^{3+} will predominate under very oxidative conditions with Eh > 400 mV and pH <2. Since Figures 1 and 2 show that the average Eh and pH during the study were 65 mV and 6 respectively, hence the dominant iron compound was Fe^{2+}. According to the calculation of Fe content in water during rice growth (calculation was based on the results of the solubility times $[Fe^{3+}] [OH^-]^3 = 10^{-38}$), this indicates that Fe^{2+} was always more dominant than Fe^{3+}. The highest Fe^{2+} content was 4 ppm, but Fe^{3+} was only 2.8×10^{-13}, hence there was no chance of iron poisoning. This is supported by Sulaiman at al. (1997) that the critical limit of toxicity to the soil was 260 ppm. Herviyanti & Asmar (2005) which reported that soil Fe^{2+} content ranged from 126.67 - 305.30 ppm, after flooding for 30 days and extracted with 1 M $CH_3COOHNa$ pH 2.8 at Ultisols treated with a polysaccharide.

Furthermore, the addition of bottom ash alone did not affect all the soil chemical parameters, while the addition of cow manure compost alone has been shown to increase the soil pH, exchangeable cation (K, Na, Ca), base saturation and decrease the soil exchangeable-H after harvest (Table 5 and 6). Simanungkalit et al. (2006) explained that the general characteristics of compost which contain nutrients in types and quantities vary depending on the original material, provide nutrients slowly (slow release) and in limited quantities, and have the main function of improving soil fertility. The increased pH was due to the contribution of OH^- ions released by organic materials. The addition cow manure compost as organic material could increase the exchangeable alkaline cations such as K, Ca and Na (Table 6) which can bind and release these elements. 5 and 10 tons ha^{-1} of cow manure compost increased exchangeable-Ca by 0.11 and 0.24 $cmol^{(+)}$ kg^{-1}, and base saturation by 0.7 and 1.7 %, respectively. Munawar (2011) states that the ability of organic matter to interact with positively charged ions makes nutrients easily available to plants. Furthermore, applying cow manure compost can reduce exchangeable-Fe, and this was supported by Tan (1998) which state organic compounds in acid soils will affect metal fractions so that metals availability decreases.

The interaction of bottom ash and cow manure compost addition did not affect the paddy yield, but only the addition of cow manure compost increased the panicles number, length, and weight, pithy rice weight (Table 7). Meanwhile, the addition of bottom ash alone did not affect the yield. According to Herviyanti & Asmar (2005), 225 ppm of the non-ionic organic compound (polysaccharide) in new-established rice field increased grain weight by 2.95 g pot^{-1} and pithy rice by 35%. The plants were thought to experiencing Mn toxicity since the soil Mn_{DTPA} was higher than Fe_{DTPA} (Figure 5 and 6). The average of Fe content during this study was 60 ppm, and hence Fe toxicity has not occurred (critical limit= 260 ppm, Sulaiman et al., 1997), but Mn toxicity was taken place since its mean content was of 600 ppm (critical limit= 15-60 ppm, (Black, 1968)). This is supported by Jugsujinda & Patrick Jr. (1993) stating that rice plants would have the Fe and Mn toxicity if exceeding the threshold, 2.500 ppm for Fe and 300 ppm for Mn. Tanaka & Navasero (1966) added that there was an antagonistic reaction in the absorption of these elements, the symptoms of iron toxicity and manganese deficiency differ.

CONCLUSION

The addition of bottom ash and cow manure compost at the dosage in this study was not able to reduce the levels of Fe_{DTPA} and Mn_{DTPA} at newly established rice fields. However, the application of cow manure compost significantly increased soil pH, exchangeable cation (K, Na, Ca), base saturation and decreased exchangeable-H. The addition of bottom ash does not affect paddy yield, while cow manure compost up to 10 tons ha^{-1} increased panicle and straw dry weight.

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