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Effects of biochar and chicken litter ash on selected soil chemical properties and nutrients uptake by *Oryza sativa* L. var. MR 219

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Abstract

Environmental pollution caused by chemical fertilizers and public awareness of healthy food has created an interest in the use of organic fertilizers in agriculture. Biochar should be considered as an alternative of chemical fertilizers in agriculture because biochar applications can improve soil properties and plant productivity. The objective of this greenhouse study was to determine the effects of biochar and chicken litter ash on selected soil chemical properties and nutrients uptake of rice plants (*Oryza sativa* L. var. MR 219). Treatments evaluated were: soil only, normal fertilization, 7, 6, 5, 4, 3, and 2 tons ha^{-1} of biochar. The biochar treatments were supplemented with chicken litter ash at a rate of 5 tons ha^{-1}. Biochar amended with chicken litter ash showed positive effect on soil pH, EC, TOC, exchangeable acidity, and exchangeable Al. The different rates of amended biochar increased K uptake regardless of plant parts. However, the chemical fertilization increased N, P, Ca, and Mg uptake. Although the chemical fertilization increased most nutrients uptake, organic amendment treatments could be a better alternative in the long term because the amended biochar requires a time to decompose to release nutrients for plant uptake whereas chemical fertilizer is rapidly soluble in soil. Moreover, chemical fertilizers provide short term results however, in the long run, it will damage the soil, groundwater, and human health. Therefore, further investigation is essential to understand the influence of biochar in field trial in the long term (2 or 3 cycle) and the complete cycle of rice cultivation.

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Introduction

Rice is the main staple food crop in the world and the crop is closely associated with the culture of billions of people around the world, particularly in Asia (IRRI, 2002). Rice is grown in many different locations and under a variety of climates because the rice plant is highly adaptable to local environment. Rice is normally grown under moderate submerged conditions. It also can be grown under upland conditions or in 1 to 1.5 m deep water (IRRI, 2002).

In 2012, the planted area of paddy in Malaysia was increased by 48,000 hectares from 6,875,000 hectares in 2011. The production of rice was also increased to 27,504,000 tons (6.6%) in 2012 (Department of Statistics Malaysia, 2013). The average rice production in Malaysia is about 4 to 5 tons per hectare (MADA, 2013). Nevertheless, Malaysia still remains a major importer of rice. The Tenth Malaysia Plan stipulates that self-sufficiency level of rice is 70%, whereas the remaining 30% is imported because rice production in Malaysia is still unable to meet the needs of the country. Therefore, Malaysia has to increase her rice productivity so as to fulfill the rice demand of the growing population and to guarantee the national food security.

To increase rice production, many factors can contribute to enhancing the quality and quantity of this crop. For instance, the use of agricultural inputs such as chemical fertilizers has been emphasized. However, excessive use of fertilizers does not only waste limited resources, but it also increases cost of production besides polluting the environment. Hence, sustainable cropping and land management is needed to resolve this problem.

In recent times, the use of biochar in agriculture is on the rise. According to the European Biochar Certificate (2003), biochar is a charcoal-like substance that is pyrolysed from sustainably obtained biomass under controlled conditions and is used for any purpose which does not involve its rapid mineralization to CO_2. It is an effective materials for sustainable agriculture in the long term because it increases soil C sequestration, improves soil quality, and reducing greenhouse gas emissions (Jeffery *et al.,* 2014). Furthermore, it can improve plant productivity directly as a result of its nutrient contents which are released timely for optimum plant uptake (Lehmann *et al.,* 2003). The large surface area and pore structure of biochar also provide a habitat for beneficial soil microorganisms and this improves the rhizosphere of plants that can enhanced soil biological activity (Lehmann *et al.,* 2011).

Asai *et al.* (2009) stated that combining biochar with other organic materials will promote the productive management for crop production. Ash is one of the organic materials that could potentially be used as a fertilizer for the crops (Schiemenz and Eicler-Lobermann, 2010) but few studies had been carried out to determine the fertilizing effect of ash. In a laboratory experiment, Codling (2006) reported that poultry litter ash contained high levels of P although most of this P is water insoluble. However, it was successfully used as a P source for wheat in a previous pot study (Codling *et al.,* 2002). Faridullah *et al.* (2009) reported that chicken and duck litter ashes could be used as nutrient sources for Japanese mustard spinach. Other biomass ashes have also been successfully utilized as nutrient sources for agronomic crops (Schiemenz and Eichler-Lobermann, 2010). In addition, chicken litter ash could potentially be utilized as a liming material because of its high pH and alkalinity (Codling, 2006; Faridullah *et al.,* 2009).

Biochar and chicken litter ash have a great potential as an organic fertilizer for crops as they will create more sustainable and environmentally friendly practices in agriculture. Therefore, we hypothesized that biochar amended with chicken litter ash could improve on soil chemical properties and nutrients uptake of rice plants especially those that are cultivated on tropical acid soils with high nutrients fixing capacity. To this end, the objective of this study was to determine the effects of biochar amended with chicken litter ash on selected soil chemical properties and nutrients uptake of rice plants in a pot experiment.

Materials and methods

Selected Chemical Properties of Soil and Biochar

The soil used in this study was Bekenu Series (*Typic Paleudults*). The soil was sampled at 0 – 20 cm depth from an uncultivated area at Universiti Putra Malaysia Bintulu Campus Sarawak, Malaysia. The soil was air dried and ground to pass a 2.0 mm sieve for initial characterization. Field capacity and bulk density of the soil were determined by the method described by Tan (2005). Soil texture was determined using the hydrometer method (Bouyoucos, 1962). The pH of the soil was determined in a ratio of 1:2 (soil: distilled water suspension) using a digital pH meter (Peech, 1965). Total organic matter and total organic carbon were determined using the combustion method (Piccolo, 1996). Total N was determined using the Kjeldahl method (Bremner, 1965). Soil available P and exchangeable cations were extracted using the double acid method (Tan, 2005) followed by the blue method (Murphy and Riley, 1962) to determined P whereas exchangeable cations were determined using Atomic Absorption Spectrophotometry (AAS). Soil CEC was determined using the leaching method (Cottenie, 1980) followed by steam distillation (Bremner, 1965). The selected chemical properties of the soil are summarized in Table 2. The commercial biochar which is derived from chicken litter was used in this experiment and the chemical composition of the biochar are summarized in Table 3. This biochar was exported from Australia.

Characterization of Ash derived from Chicken Litter

The chicken litter used in this study obtained from University Agricultural Park, Universiti Putra Malaysia Bintulu Sarawak Campus. The chicken litter was incinerated in a clay pots for 9 hours afterwhich the ash was collected and sieved to pass a 2 mm sieve. The chicken litter ash was analyzed for pH, EC, total C and total N using the method previously cited. The single dry ashing method (Tan, 2005) was use to extract P, K, Ca, Mg, Na, Zn, Cu, and Fe in the chicken litter ash. The filtrates were analyzed for K, Ca, Mg, Na, Zn, Cu, and Fe using AAS whereas P was determined using the blue method (Murphy and Riley, 1962).

Pot Trial

The pot experiment was conducted in a greenhouse at Universiti Putra Malaysia, Bintulu Sarawak Campus, Malaysia. The treatments evaluated in this pot experiment were arranged in Completely Randomized Design (CRD) with three replications. The details of the treatments are as follows:

T1 = Soil only

T2 = Normal fertilization as recommended by MADA (2013)

T3 = 7 tons ha^{-1} of biochar (28g pot^{-1}) + 5 tons ha^{-1} chicken litter ash (20g pot^{-1})

T4 = 6 tons ha^{-1} of biochar (24g pot^{-1}) + 5 tons ha^{-1} chicken litter ash (20g pot^{-1})

T5 = 5 tons ha^{-1} of biochar (20g pot^{-1}) + 5 tons ha^{-1} chicken litter ash (20g pot^{-1})

T6 = 4 tons ha^{-1} of biochar (16g pot^{-1}) + 5 tons ha^{-1} chicken litter ash (20g pot^{-1})

T7 = 3 tons ha^{-1} of biochar (12g pot^{-1}) + 5 tons ha^{-1} chicken litter ash (20g pot^{-1})

T8 = 2 tons ha^{-1} of biochar (8g pot^{-1}) + 5 tons ha^{-1} chicken litter ash (20g pot^{-1})

Based on the soil bulk density, plastic pots (slope-sided) measuring 5.65 cm height, 14 cm diameter at the top and 9.3 cm at the base were filled with 1 kg of Bekenu Series soil. The treatments were scaled down to per pot basis. The biochar was thoroughly mixed with the soil afterwhich the mixture was transferred to the plastic pots. The pots were arranged inside plastics trays (measuring 41 cm in length x 30.5 cm in width x 11.3 cm in height). The soils in the plastic pots were flooded to 3 cm water above the surface and the plastics trays were also filled with water to the same water level inside the pots. Water level in the pots and trays were maintained throughout this study. The rice seedlings used in this study were from MR 219 variety. At 14 days of the nursing, the seedlings were transplanted to the pots and each pot was planted with 3 seedlings per hill. The depth of planting was 2 cm.

The recommended rice fertilization by MADA (2013) is presented in Table 1. For T2, the compound fertilizer was substituted chemical fertilizers, comprising N as Urea, P as Egypt Rock Phosphate (ERP), K as Muriate of Potash (MOP), and Mg as Kieserite. The nutrient requirement was calculated and also scaled down to per pot basis. The treatments were applied in stages. For T2, fertilizations were carried out at 15, 35, 50 and 70 days after transplanting (DAT) whereas for T3 – T8, they were applied a day before transplanting and when the symptoms of nutrient deficiency showed (0, 31, 38, 45, 50, 57, and 70 DAT).

Data Collection and Analysis

After transplanting, MR 219 plants were monitored for 78 days. At 78 days of planting, soil samples were taken and analyzed for pH, EC, total organic carbon, total N, available P, exchangeable K, Mg, Ca, and Mg using the methods described previously. Soil exchangeable acidity and Al were determined using the titration method described by Rowell (1994). Plants were harvested before panicle initiation (78 DAT) and partitioned into roots and aboveground biomass. Selected plant growth variables data were collected (Table 4). Standard procedures were used to determine the dry weight of the plant parts. The single dry ashing method was used to extract K, Ca, Mg, and Na from the plant parts afterwhich AAS was used to determine the concentrations of these nutrients whereas total P was determined by using UV-Vis spectrometer after blue colour development (Murphy and Riley, 1962). The Kjeldahl method was used to determine the total N of the plant parts. The concentrations of N, P, K, Ca, and Mg in the plant parts multiplied by their dry matter provided the amounts of these nutrients taken up by the plant parts.

Statistical Analysis

The data are presented as means ± standard error of the mean. Analysis of variance (ANOVA) was used to detect treatment effects whereas Tukey's test was used to compare treatment means at $P \leq 0.05$. The Statistical Analysis System version 9.2 was used for the statistical tests.

Results and discussion

Characteristics of Soil and Organic Amendments

The selected physico-chemical properties of Bekenu series are shown in Table 2. The soil pH in water, CEC, and total N were 4.11, 7.33 cmol kg^{-1}, and 0.15%, respectively. These results are consisted with those reported by Paramananthan (2000) except for exchangeable Ca. The texture of the soil was sandy clay loam with a bulk density of 1.51 g m^{-3}. The texture of the soil and bulk density are consistent with those reported in Soil Survey Staff (2014).

Table 1. Fertilization schedule recommended by MADA (2013) for rice variety MR 219.

Crop Level	Days After Transplanting (DAT)	Fertilizer Type	Application Rates (kg/ha)	Scale Down Rates (g/pot)
Start growth	15 to 20	Mixture Fertilizers (Government Aid) 17.5 N: 15.5 P_2O_5: 10 K_2O	360 kg	0.55 g Urea + 0.5 g TSP + 0.24 g MOP
Active growth	35 to 40	Urea (Government Aid)	100 kg	0.4 g
Formation of stalk	50 to 55	Additional substance of fertilizer 12:12:17:2 MgO + TE	175 kg	0.18 g Urea + 0.19 g TSP + 0.2 g MOP + 0.054 g Kieserite
Seed filling	70 to 75	Additional substance of fertilizer 12:12:17:2 MgO + TE	175 kg	0.18 g Urea + 0.19 g TSP + 0.2 g MOP + 0.054 g Kieserite

Table 3 shows the selected properties of the commercialize chicken litter biochar and chicken litter ash. Both of these organic materials were high in pH suggesting their potential as liming materials (Codling, 2006; Faridullah *et al.,* 2009). The total organic C of the chicken litter biochar was higher than that of the chicken litter ash. However, total N concentration of both products was low. This shows that N was gasified as nitrogen during combustion process. Total P and K of the chicken litter ash were higher than those of the chicken litter biochar indicating a possibility of being ideal material for P and K. Calcium, Mg, Zn, and Cu of the chicken litter ash were higher whereas Na and Fe were lower than those of the chicken litter biochar.

Table 2. Selected physico - chemical properties of Bekenu Series.

Property	Value obtained	Standard data range*
pH_{water}	4.11	4.6 – 4.9
CEC (cmol kg^{-1})	7.33	3.86 – 8.46
Texture	SCL	SCL
Bulk Density (g cm^{-3})	1.51	nd
Total N (%)	0.15	0.04 – 0.17
Available P (mg kg^{-1})	2.39	nd
Exchangeable K (mg kg^{-1})	0.16	0.05 – 0.19
Exchangeable Ca (mg kg^{-1})	2.05	0.05 – 0.19
Exchangeable Mg (mg kg^{-1})	0.18	0.07 – 0.21
Total Organic Carbon (%)	1.2	0.57 – 2.51

Note: *Standard data reported by Paramanathan (2000); nd, not determined; SCL, Sandy Clay Loam

Table 3. Selected chemical properties of chicken litter biochar and chicken litter ash.

Property	Chicken litter biochar	Chicken litter ash
pH	8.5	8.9
Electrical Conductivity (dS m^{-1})	15.5	58.2
Total Carbon (%)	63.7	0.4
Total N (%)	2.8	2.8
Total P (%)	2.6	5.1
C/N ratio	22.8	0.1
C/P ratio	24.5	0.1
Total K (%)	3.9	5.8
Total Ca (%)	5.9	6
Total Mg (g kg^{-1})	15.2	15.9
Total Na (g kg^{-1})	19.5	1.4
Total Zn (mg kg^{-1})	856	4440
Total Cu (mg kg^{-1})	167	516
Total Fe (mg kg^{-1})	2650	1868

Effects of Organic Amendments on Selected Rice Plant Growth Variables

Significant differences among treatments were observed in the rice plant height, number of leaves and numbers of tillers (Table 4). T2 (chemical fertilizer) showed the highest number of tillers and number of leaves compared to the different rates of biochar. However, T2 had no significant effect on plant height (Table 4). The different rates of the biochar used did not significantly affect the rice plant height, number of leaves, and number of tillers.

Treatments Effect on Dry Weight and Selected Chemical Properties on rice plant biomass

T2 showed the highest dry weight of aboveground biomass compared to the different rates of biochar and soil only treatments (Table 5). Similar observation was observed in the dry weight of belowground biomass (Table 6). This observation is consistent with the findings in number of tillers and number of leaves (Table 4). The biochar treatments (regardless of the different rates of biochar) showed the highest amount of K in the aboveground biomass compared to T2 and T1. This finding is consistent to that of K in belowground biomass (Table 6). This was due to the high inherent content of K in the biochar and chicken litter ash (Table 3). The application of chemical fertilizers and the different rates of biochar have no significant effect on N, Ca, Mg, Na, and Zn concentrations in the aboveground biomass. The belowground biomass also showed similar finding except for Ca. The Ca amount of belowground biomass in of the different rates of biochar (T3, T4, T5, T6, T7, and T8) was higher compared to T2 and T1. In terms of P, soils with chemical fertilizers (T2) and different rates of biochar showed higher content of P compared to soil without fertilization (T1).

Table 4. Effects chemical fertilization and different rates of biochar on the selected growth variables of *Oryza sativa* var. MR 219 at 78 days.

Treatment Code	No. of tillers	No. of leaves	Plant height (cm)
T1	3 ^{c} ± 0	16.67 ^{d} ± 0.33	62.33 ^{c} ± 3.33
T2	10 ^{a} ± 0	54 ^{a} ± 3.06	82.83 ^{a} ± 2.49
T3	6.67 ^{b} ± 0.33	31.67 ^{b} ± 0.67	71.67 ^{b} ± 0.33
T4	6.67 ^{b} ± 0.33	30 ^{bc} ± 0	74 ^{b} ± 1
T5	6.33 ^{b} ± 0.33	28.33 ^{bc} ± 1.86	73.5 ^{b} ± 0.5
T6	6.67 ^{b} ± 0.33	36.33 ^{b} ± 1.67	77 ^{ab} ± 0.58
T7	7 ^{b} ± 1	26.33 ^{bcd} ± 4.1	79.33 ^{ab} ± 0.88
T8	5 ^{bc} ± 0.58	20.33 ^{cd} ± 1.86	76.33 ^{ab} ± 1.2

Means within column with different letter(s) indicate significant difference between treatments by Tukey's test at $P \le 0.05$.

Table 5. Dry weight and nutrient concentration (aboveground biomass) of *Oryza sativa* var. MR 219 at harvesting (78 days).

Treatment Code	Dry weight (g pot^{-1})	N %	P %	K %	Ca %	Mg %	Na (ppm)	Zn (ppm)
T1	4.767 ^{d} ± 0.498	0.934 ^{a} ± 0.124	0.065 ^{d} ± 0.001	0.611 ^{c} ± 0.01	0.102 ^{ab} ± 0.021	0.128 ^{a} ± 0.004	1146.67 ^{abc} ± 110.504	47.7 ^{a} ± 1.026
T2	20.7 ^{a} ± 1.966	0.841 ^{ab} ± 0.081	0.113 ^{b} ± 0.004	0.97 ^{b} ± 0.085	0.147 ^{a} ± 0.036	0.135 ^{a} ± 0.006	940 ^{bc} ± 142.244	44.767 ^{ab} ± 9.524
T3	10.767 ^{bc} ± 0.644	0.42 ^{b} ± 0	0.112 ^{b} ± 0.003	1.483 ^{a} ± 0.061	0.038 ^{b} ± 0.022	0.118 ^{a} ± 0.005	1190 ^{abc} ± 147.986	27.333 ^{b} ± 1.217
T4	11.267 ^{bc} ± 0.133	0.56 ^{ab} ± 0	0.126 ^{ab} ± 0.001	1.447 ^{a} ± 0.03	0.051 ^{ab} ± 0.004	0.125 ^{a} ± 0.002	940 ^{bc} ± 166.233	34.433 ^{ab} ± 0.825
T5	10.967 ^{bc} ± 0.376	0.514 ^{ab} ± 0.124	0.131 ^{a} ± 0.003	1.416 ^{a} ± 0.045	0.045 ^{b} ± 0.002	0.127 ^{a} ± 0.004	736.667 ^{c} ± 12.019	39.967 ^{ab} ± 0.581
T6	13.667 ^{b} ± 0.788	0.467 ^{b} ± 0.047	0.115 ^{b} ± 0.004	1.457 ^{a} ± 0.009	0.078 ^{ab} ± 0.011	0.138 ^{a} ± 0.003	1226.67 ^{abc} ± 58.405	29.533 ^{b} ± 3.061
T7	10.667 ^{bc} ± 1.068	0.607 ^{ab} ± 0.047	0.094 ^{c} ± 0.004	1.489 ^{a} ± 0.042	0.04 ^{b} ± 0.013	0.121 ^{a} ± 0.004	1426.67 ^{ab} ± 145.297	34.5 ^{ab} ± 1.646
T8	8.367 ^{cd} ± 1.168	0.42 ^{b} ± 0.14	0.086 ^{c} ± 0.002	1.52 ^{a} ± 0.032	0.089 ^{ab} ± 0.026	0.128 ^{a} ± 0.004	1553.33 ^{a} ± 72.188	32.067 ^{ab} ± 1.472

Means within column with different letter(s) indicate significant difference between treatments by Tukey's test at $P \le 0.05$.

Table 6. Dry weight and nutrient concentration (belowground biomass) of *Oryza sativa* var. MR 219 at harvesting (78 days).

Treatment Code	Dry weight (g pot^{-1})	N %	P %	K %	Ca %	Mg %	Na (ppm)	Zn (ppm)
T1	3.567 ^{e} ± 0.689	0.42 ^{a} ± 0	0.028 ^{d} ± 0.002	0.238 ^{b} ± 0.009	0.005 ^{c} ± 0.001	0.079 ^{ab} ± 0.005	2820 ^{c} ± 70.946	4.43 ^{b} ± 4.43
T2	17 ^{a} ± 1.041	0.28 ^{b} ± 0	0.047 ^{c} ± 0.004	0.311 ^{b} ± 0.018	0.004 ^{c} ± 0	0.071 ^{b} ± 0.002	2723.33 ^{c} ± 122.384	7.018 ^{b} ± 7.018
T3	7.7 ^{bcd} ± 0.4	0.28 ^{b} ± 0	0.07 ^{ab} ± 0.003	0.797 ^{a} ± 0.026	0.015 ^{b} ± 0.001	0.102 ^{a} ± 0.003	3256.67 ^{abc} ± 14.53	4.005 ^{a} ± 4.005
T4	4.7 ^{de} ± 0.153	0.327 ^{ab} ± 0.047	0.072 ^{a} ± 0.003	0.81 ^{a} ± 0.066	0.022 ^{a} ± 0.002	0.098 ^{a} ± 0.007	3140 ^{bc} ± 66.583	15.346 ^{a} ± 15.346
T5	7.6 ^{bcd} ± 0.153	0.28 ^{b} ± 0	0.08 ^{a} ± 0.002	0.777 ^{a} ± 0.02	0.015 ^{ab} ± 0.001	0.099 ^{a} ± 0.001	3306.67 ^{abc} ± 49.103	8.199 ^{a} ± 8.199
T6	9.3 ^{b} ± 0.52	0.234 ^{b} ± 0.047	0.066 ^{ab} ± 0.002	0.79 ^{a} ± 0.051	0.013 ^{b} ± 0.001	0.101 ^{a} ± 0.01	3436.67 ^{ab} ± 171.691	4.558 ^{ab} ± 4.558
T7	8.233 ^{bc} ± 0.669	0.28 ^{b} ± 0	0.08 ^{a} ± 0.002	0.754 ^{a} ± 0.114	0.013 ^{b} ± 0.001	0.098 ^{a} ± 0.003	3753.33 ^{a} ± 246.667	6.452 ^{ab} ± 6.452
T8	5.567 ^{cde} ± 0.895	0.28 ^{b} ± 0	0.054 ^{bc} ± 0.005	0.837 ^{a} ± 0.024	0.018 ^{ab} ± 0.002	0.084 ^{ab} ± 0.003	3513.33 ^{ab} ± 76.884	3.583 ^{ab} ± 3.583

Means within column with different letter(s) indicate significant difference between treatments by Tukey's test at $P \le 0.05$.

Effects of Treatments on Selected Nutrient Uptake

The results of the selected nutrient uptake in aboveground biomass are shown in Table 7. The soil with chemical fertilizers recorded the highest N, P, Ca, and Mg uptake regardless of rice plant part (Tables 7 and 8). This is possible because root biomass is closely related to plant nutrient uptake. As discussed previously, chemical fertilization showed a superior roots dry weight (Table 6) and this may cause to the improved of nutrients uptake as timely nutrient supply ultimately determines nutrient uptake. However, root biomass including mycorrhizae is one of the key factors that controls the plant nutrients uptake as large root biomass is the main mechanism by which plants minimize diffusional limitations of nutrient delivery to root surface (Lambers, 2008). As shown in previous studies (Lehmann *et al.,* 2003; Rondon *et al.,* 2007), application of biochar led to lower N uptake. The similar results found in this study regardless of the rates of biochar was due to the lower content of N in the biochar. High C/N ratio of the biochar may cause N immobilization (Lehmann *et al.,* 2003). In terms of P uptake by plant roots, the effect of T2 was similar to T5, T6, and T7. However, the organic amendments significantly improved K uptake in the above and roots biomass compared that of the chemical fertilizer. This is due to high K content of the biochar and chicken litter ash (Table 3). Available K in biochar typically high and increased K uptake as a result of biochar application has been frequently reported (Lehmann *et al.,* 2003; Chan *et al.,* 2007). Interestingly, Ca uptake in roots was not affected by the biochar rates.

Table 7. Effects chemical fertilization and different rates of biochar on selected nutrients uptake on *Oryza sativa* var. MR 219 aboveground biomass at harvesting (78 days).

Treatment Code	N (g plant^{-1})	P (g plant^{-1})	K (g plant^{-1})	Ca (g plant^{-1})	Mg (g plant^{-1})
T1	4.567 ^{b} ± 1.036	0.31 ^{e} ± 0.035	2.908 ^{b} ± 0.289	0.507 ^{b} ± 0.16	0.608 ^{d} ± 0.045
T2	17.195 ^{a} ± 1.447	2.316 ^{a} ± 0.152	20.38 ^{a} ± 3.397	2.936 ^{a} ± 0.662	2.779 ^{a} ± 0.158
T3	4.525 ^{b} ± 0.27	1.213 ^{bcd} ± 0.096	16.032 ^{a} ± 1.548	0.413 ^{b} ± 0.252	1.274 ^{c} ± 0.093
T4	6.314 ^{b} ± 0.075	1.418 ^{bc} ± 0.005	16.297 ^{a} ± 0.217	0.572 ^{b} ± 0.046	1.412 ^{bc} ± 0.03
T5	5.698 ^{b} ± 1.448	1.431 ^{bc} ± 0.047	15.547 ^{a} ± 0.91	0.495 ^{b} ± 0.01	1.392 ^{bc} ± 0.055
T6	6.314 ^{b} ± 0.288	1.578 ^{b} ± 0.144	19.93 ^{a} ± 1.259	1.056 ^{b} ± 0.154	1.89 ^{b} ± 0.103
T7	6.431 ^{b} ± 0.564	1.011 ^{cd} ± 0.144	15.886 ^{a} ± 1.63	0.45 ^{b} ± 0.196	1.286 ^{c} ± 0.109
T8	3.339 ^{b} ± 0.863	0.717 ^{de} ± 0.105	12.727 ^{a} ± 1.833	0.799 ^{b} ± 0.34	1.082 ^{cd} ± 0.182

Means within column with different letter(s) indicate significant difference between treatments by Tukey's test at $P \leq 0.05$.

Table 8. Effects chemical fertilization and different rates of biochar on selected nutrients uptake on *Oryza sativa* var. MR 219 plant roots at harvesting (78 days).

Treatment Code	N (g plant^{-1})	P (g plant^{-1})	K (g plant^{-1})	Ca (g plant^{-1})	Mg (g plant^{-1})
T1	1.499 ^{b} ± 0.289	0.096 ^{e} ± 0.012	0.846 ^{c} ± 0.154	0.017 ^{b} ± 0.001	0.279 ^{d} ± 0.043
T2	4.763 ^{a} ± 0.292	0.8 ^{a} ± 0.081	5.245 ^{ab} ± 0.039	0.07 ^{ab} ± 0.005	1.21 ^{a} ± 0.098
T3	2.158 ^{b} ± 0.112	0.535 ^{bc} ± 0.034	6.123 ^{ab} ± 0.277	0.113 ^{a} ± 0.008	0.782 ^{bc} ± 0.037
T4	1.522 ^{b} ± 0.164	0.34 ^{cd} ± 0.014	3.809 ^{bc} ± 0.36	0.101 ^{a} ± 0.006	0.458 ^{cd} ± 0.036
T5	2.13 ^{b} ± 0.043	0.61 ^{ab} ± 0.029	5.899 ^{ab} ± 0.038	0.118 ^{a} ± 0.006	0.75 ^{bc} ± 0.018
T6	2.214 ^{b} ± 0.523	0.608 ^{ab} ± 0.018	7.326 ^{a} ± 0.484	0.121 ^{a} ± 0.005	0.951 ^{ab} ± 0.136
T7	2.307 ^{b} ± 0.188	0.658 ^{ab} ± 0.048	6.307 ^{ab} ± 1.397	0.103 ^{a} ± 0.01	0.808 ^{bc} ± 0.091
T8	1.56 ^{b} ± 0.251	0.31 ^{de} ± 0.071	4.66 ^{ab} ± 0.758	0.102 ^{a} ± 0.026	0.467 ^{cd} ± 0.08

Means within column with different letter(s) indicate significant difference between treatments by Tukey's test at $P \leq 0.05$.

Treatments Effect on Selected Soil Chemical Properties

The selected soil chemical properties status after the experiment are presented in the Table 9. Generally, the primary macronutrients in the soil show no significant differences within biochar rates. The similar result was also found in Ca concentration of the soil. However, P, K, and Ca accumulation in soil treated with different rates of biochar were significantly different compared to T2 whereas Mg was non-significant. However, the different rates of biochar significantly increased soil pH and EC. The increase in soil pH was due to rapid proton (H^+) exchange between soil and the organic amendments (Tang *et al.,* 1999; Wong *et al.,* 1998). The higher Ca content in the biochar and chicken litter ash might have contributed to the increase in soil pH. Exchangeable Al was lower in the soil treated with different rates of biochar was because of the increase in soil pH as negative relationship between soil pH and soil exchangeable Al had been reported by Zeng *et al.* (2005). Biochar rates also found significantly improved TOC in the soil.

Table 9. Effects of chemical and organic fertilization on selected soil chemical properties after experiment.

	Treatment Code							
Property	T1	T2	T3	T4	T5	T6	T7	T8
N (%)	$0.056^{b} \pm 0$	$0.0934^{a} \pm 0.0093$	$0.0654^{ab} \pm 0.0094$	$0.0841^{ab} \pm 0$	$0.0841^{ab} \pm 0$	$0.0841^{ab} \pm 0$	$0.0747^{ab} \pm 0.0094$	$0.0747^{ab} \pm 0.0094$
P (%)	$0.0003^{b} \pm 0$	$0.0022^{a} \pm 0.0001$	$0.0003^{b} \pm 0$	$0.0003^{b} \pm 0$	$0.0003^{b} \pm 0$	$0.0003^{b} \pm 0$	$0.0002^{b} \pm 0$	$0.0002^{b} \pm 0$
K (%)	$0.0011^{b} \pm 0.0001$	$0.0002^{c} \pm 0$	$0.0014^{a} \pm 0.0001$	$0.0015^{a} \pm 0$	$0.0013^{ab} \pm 0.0001$	$0.0013^{ab} \pm 0$	$0.0013^{ab} \pm 0.0001$	$0.0014^{a} \pm 0.0001$
Ca (%)	$0.0049^{b} \pm 0.0004$	$0.0148^{b} \pm 0.0004$	$0.1491^{a} \pm 0.0024$	$0.1347^{a} \pm 0.0097$	$0.1385^{a} \pm 0.0034$	$0.1457^{a} \pm 0.0028$	$0.1318^{a} \pm 0.0017$	$0.1326^{a} \pm 0.0033$
Mg (%)	$0.0061^{b} \pm 0.001$	$0.0072^{b} \pm 0.0011$	$0.0081^{b} \pm 0.0004$	$0.0097^{ab} \pm 0.0007$	$0.0088^{ab} \pm 0.0002$	$0.0119^{a} \pm 0.0003$	$0.0088^{ab} \pm 0.0012$	$0.0097^{ab} \pm 0.0003$
pH	$5.7467^{b} \pm 0.0717$	$4.9433^{c} \pm 0.0546$	$7.38^{a} \pm 0.0058$	$7.51^{a} \pm 0.0493$	$7.4867^{a} \pm 0.0186$	$7.5067^{a} \pm 0.0233$	$7.4833^{a} \pm 0.0426$	$7.5667^{a} \pm 0.0233$
EC (dS m-1)	$0.0363^{b} \pm 0.0021$	$0.1268^{b} \pm 0.0061$	$0.617^{a} \pm 0.0347$	$0.7403^{a} \pm 0.0271$	$0.6923^{a} \pm 0.0293$	$0.6917^{a} \pm 0.0094$	$0.7217^{a} \pm 0.0448$	$0.719^{a} \pm 0.0225$
TOC (%)	$1.5741^{bc} \pm 0.0267$	$1.7275^{abc} \pm 0.024$	$1.7409^{ab} \pm 0.0529$	$1.8209^{a} \pm 0.0611$	$1.7609^{ab} \pm 0.0306$	$1.5408^{c} \pm 0.02$	$1.0205^{d} \pm 0.0504$	$0.9872^{d} \pm 0.0176$
Exchangeable Acidity (cmol kg-1)	$1.2733^{a} \pm 0.0533$	$1.2733^{a} \pm 0.0437$	$0.2267^{b} \pm 0.0333$	$0.24^{b} \pm 0$	$0.22^{b} \pm 0$	$0.24^{b} \pm 0$	$0.22^{b} \pm 0.0115$	$0.2267^{b} \pm 0.0067$
Exchangeable Al (cmol kg-1)	$0.0333^{a} \pm 0.0067$	$0.0333^{a} \pm 0.0067$	$0.02^{a} \pm 0$	$0.02^{a} \pm 0$	$0.02^{a} \pm 0$	$0.02^{a} \pm 0$	$0.02^{a} \pm 0$	$0.02^{a} \pm 0$

Means within column with different letter(s) indicate significant difference between treatments by Tukey's test at $P \leq 0.05$.

Conclusion

Biochar amended with chicken litter ash showed positive effect soil pH, EC, TOC, exchangeable acidity, and exchangeable Al. In terms of nutrients uptake, the different rates of amended biochar increased K uptake regardless of plant parts. However, the chemical fertilization increased N, P, Ca, and Mg uptake. Although the chemical fertilization increased most nutrients uptake, organic amendment treatments could be a better alternative in the long term because the amended biochar requires a time to decompose to release nutrients for plant uptake whereas chemical fertilizer is rapidly soluble in soil. In addition, chemical fertilizers provide short term results however, in the long run, it will damage the soil, groundwater, and human health. Therefore, further investigation is essential to understand the influence of biochar in field trial in the long term (2 or 3 cycle) and the complete cycle of rice cultivation.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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