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Adsorption Characteristics of Ammonium Nitrogen and Plant Responses to Biochar Pellet

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Abstract: For feasibility of carbon sequestration as well as in the mitigation of greenhouse gases for application of biochar pellet, this experiment was conducted, focusing on the adsorption characteristics of NH_4-N on biochar pellet mixed with different ratios of pig manure compost. For NH_4-N adsorption on biochar pellets, the loading amount of biochar pellet was 211.5 mg in 50 mL of aqueous solution, and the adsorption fitted very well with Langmuir isotherm. The maximum adsorption and removal rates were 2.94 mg g^{-1} and 92.2%, respectively, in the pellet that contained 90% of biochar. It was also observed, by kinetic models, that NH_4-N was adsorbed fast on biochar pellet with a combination ratio of 9:1 of biochar pellet/pig manure. It was further observed that the higher the amount of biochar contained in the biochar pellet, the greater the adsorption of NH_4-N. For the plant response observed for lettuce, it was shown that the leaf biomass in plots treated with a 9:1 biochar/pig manure compost increased by approximately 13% compared with the leaf biomass in plots treated with the compost alone. The leaf biomass of the other treatments was higher than that of the control. This implies that the application of biochar pellets, regardless of the biochar contents, might be useful for soil carbon sequestration and greenhouse gas mitigation for agricultural practices.

Keywords: carbon sequestration; ammonium nitrogen; biochar pellet

1. Introduction

Biomass is waste materials from agricultural products which includes agricultural residues and forest resources [1]. The byproducts from rural areas are a resource of latent energy; they can cause greenhouse gas emissions as well as agro-environmental problem [2]. MIFAFF [3] estimated that 50 million tons of organic wastes in agriculture are produced out of 80 million tones every year. The use of biomass has not only reduced the environmental problem but has also been able to convert the biomass into value-added products.

Biochar is the residual material obtained by the thermal reaction of biomass under deficiency of oxygen using biomass conversion technology. Biochar from thermal conversion technology has recently attracted attention for its potential ability of carbon sequestration, suggesting the possibility to act against climate changes through the addition of biochar into soil. Biochar's positive effects on the agro-ecosystem have been suggested to derive either from nutrients in the biochar or from its ability to control these nutrients [4]. When biochar is applied to soil, an additional application of fertilizer is still needed to increase crop yield. Many researchers investigated the value-added biochar for soil carbon sequestration, which suggested the combination of biochar with composts before soil application [5]. Biochar mixed with sludge composite into landfill was known to apparently decrease nitrogen loss [6]. However, biochar application to soil became challenging because biochar is easily breakable and produces saw dust with low density. Kamman et al. reported a 30% loss of the biochar by wind-blow during handling and especially a 25% of biochar lost for spreading of biochar in croplands [7]. In addition, a loss from 20% to 53% of biochar was measured as a consequence of runoff during intensive rain falls [8]. However, Shin [9] indicated that the total carbon incorporated by biochar during harvesting periods ranged from 0.96% to 1.24%, and its cow compost produced the highest levels at 1.24% in a corn field. It appeared that the total carbon's contents obtained with biochar treatments were higher than those obtained with the compost treatment alone. Therefore, the combination of biochar with organic composts for crop cultivation could be a potential soil carbon sequestration system in agricultural practices. Further, it is necessary to create a value-added biochar that can provide major nutrients to the plants during crop cultivation with a minimum loss. The biochar pellet is a promising way to reduce the handling costs and significantly decreases the loss of biochar during soil incorporation [10]. Biochar pellet has been mostly used as alternative heating material to biomass pellet [11].

For soil incorporation, poultry litter was mixed and slowly pyrolyzed to produce biochar pellet [12]. However, there is not sufficient research on biochar pellet to reduce nutrient release from biochar pellet to the soil throughout crop cultivation thus providing nutrients to crop growth without leaching [13], which can increase a farmer's profit and maximize to the agro-environmental health [14].

Thus, this experiment was conducted to investigate the characteristics of NH_4-N adsorption of and plant responses to a produced biochar pellet mixed with different ratios of pig manure compost before soil application for carbon sequestration.

2. Materials and Methods

2.1. Raw Materials in the Batch Experiment for Adsorption Determination

The adsorption study was conducted in deionized water with a biochar pellet mixed with different ratios of pig manure compost. The combination ratios of biochar (Φ 0.51 cm × 0.78 cm) and pig manure compost were 9:1, 8:2, 6:4, 4:6, and 2:8. The materials (total weight = 2.5 kg) were completely mixed using an agitator for 5 min. Then, while continuously mixing, the combination was sprayed with 1000 mL of deionized water for 10 min. The biochar pellet was made by pouring the mixture through the machine (7.5 KW, 10 HP) (Figure 1).

Figure 1. Processing diagram of biochar pellet with different pig compost ratios.

An amount of 50 mL of deionized water and 211.5 mg of biochar pellet which was estimated from 5500 kg ha^{-1} of recommended pig compost input in a corn field were added into 150 mL of polyethylene bottles, which were tightly capped. All bottles were transferred into a water bath shaker (JP/NTS-3000, Eyela, Kyoto, Japan) for equilibration for 6, 15, 24, 40, 72, 96, 144, 240, and 336 h at 100 rpm of agitation speed and 25 °C. Biochar from rice hull and pig manure compost was collected from a local cooperative union of famers. The chemical properties of the biochar pellets and pig manure compost used are presented in Table 1.

Table 1. Characteristics of the biochar and pig manure compost used [1].

	pH	EC	TC	TOC	TIC	TN
		(dS m^{-1})	%			
Biochar	9.78 (1:20)	16.53	56.6	52.3	4.2	0.20
Pig manure compost	8.77 (1:5)	3.40	28.9	25.9	3.0	2.91

[1] TC: Total carbon, TOC: Total organic carbon, TIC: Total inorganic carbon, and TN: Total nitrogen.

2.2. Adsorption and Removal Rates

The biochar pellets consisted of different ratio of pig manure compost. For the adsorption rate of NH_4-N to biochar pellet, the NH_4-N concentrations from different masses of pig manure composts and retention times (6–336 h) were calculated from desorption models of NH_4-N in the pig manure compost (Table 2). On the basis of the data from a batch scale experiment, estimated releasing models of NH_4-N in the different loading ratios of pig manure composts (0.1–1.5 g) were derived. From these equations, the released amount of NH_4-N from each mass of pig manure compost could be calculated, and then these equations were used for normalizing the NH_4-N contents in different ratios of biochar pellet to determine the releasing NH_4-N concentrations from biochar pellets with different retention times.

Table 2. Estimated releasing models of NH_4-N in the pig manure compost with different retention times and input amounts.

Retention Times (h)	Linear Equations	R^2
6	Y = 23.57X + 7.652	0.972 **
15	Y = 30.19X + 9.396	0.988 **
24	Y = 30.37X + 9.531	0.986 **
40	Y = 34.36X +11.166	0.965 **
72	Y = 38.50X + 10.752	0.979 **
96	Y = 39.11X + 11.714	0.989 **
144	Y = 42.37X + 12.709	0.976 **
240	Y = 55.16X + 17.575	0.953 **
336	Y = 54.63X + 24.034	0.937 **

Unit: X, g; Y, mg.

Adsorption amounts and removal rates of the biochar pellets were calculated using these data by applying Equations (1) and (2).

$$q_t = \frac{(C_0 - C_t)V}{W} \quad (1)$$

$$\%\ \text{Removal} = \frac{(C_0 - C_t)}{C_0} \times 100 \quad (2)$$

where C_0 is the initial concentration, and C_t (mg·L^{-1}) is the equilibrium concentration of NH_4-N in solution; q_t (mg·L^{-1}) is the amount of NH_4-N adsorbed at equilibrium, V (L) is the mass of solution, and W (g) is the weight of the biochar pellet.

2.3. Langmuir Isothermal

An adsorption isotherm characterizes the surface area between adsorbent and solution when the adsorption equilibrium is reached at a constant temperature and provides the parameters for optimizing the adsorption in a batch scale. The Langmuir isotherm model describes the absorption capacity of a monolayer formed between a homogeneous surface area and the adjacent adsorbates [15]. The Langmuir isotherm is derived as:

$$\frac{1}{C_e} = bq_m\frac{1}{q_e} - b \quad (3)$$

where q_e (mg/L) is NH_4-N (mg g^{-1}) adsorbed at equilibrium, q_m is the maximum monolayer adsorption capacity, b is an empirical constant representing the monolayer adsorption capacity, and C_e is the concentration of NH_4-N (mg g^{-1}) in the biochar pellet at equilibrium; $1/C_e$ and $1/q_e$ were calculated from the plot, with a straight line with slop yield q_m and b. In Langmuir isotherm model, the adsorption type is classified by a dimensionless constant factor r which is given by the below equation:

$$R_L = \frac{1}{1 + bC_0} \quad (4)$$

where C_0 is the initial adsorbate concentration.

2.4. Kinetic Models

To explain the adsorption kinetics of NH_4-N on a biochar pellet, kinetic models [16] were employed.

$$\ln(q_e - q_t) = \ln q_e - K_1 t \quad (5)$$

$$\frac{t}{q_t} = \frac{1}{K_2 q_e^2} + \frac{1}{q_e}t \quad (6)$$

where q_e (mg·g^{-1}) is the quantity of NH_4-N adsorbed at equilibrium, q_t is the absorbed amount at a given interval (t), while k_1 and k_2 are constant rates calculated from the straight-line plot of Equations (5) and (6) for the pseudo-first- and second-order models, respectively. In

$$h = K_2 q_e^2 \quad (7)$$

h is the initial absorbed amount (mg g^{-1} min^{-1}) calculated from (7) [17].

2.5. Chemical Analysis

The pH and EC (electrical conductivity) of the biochar pellet were measured using a pH/EC meter (Orion 4 star, Thermo Scientific, Singapore) at a 1:20 solid/water ratio (biochar:de-ionized H_2O) after shaking for 30 min in a water bath (JP/NTS-3000, Eyela, Kyoto, Japan) at 140 rpm. The analytical soil and biochar chemical properties, as TC and TOC, were analyzed by a TOC analyzer (Elementar Vario EL II, Hanau, Germany). The combustion temperature was 950 °C, with tungsten oxide (WO_3) used as the catalyst. Thus, TC contents were obtained. The whole samples from the absorption experiment were filtered through filter paper Whatman No. 2, and the filtrated solutions were calorimetrically analyzed to measure NH_4-N, using a UV spectrophotometer (ST-Ammonium, C-Mac, Dae-Jen, Korea) by monitoring the adsorption at 655 nm.

2.6. Lettuce Cultivation

For a bioassay test with the biochar pellets, lettuce seeds were sowed in a nursery plate with peat moss in the glass. The crop used was lettuce (*Lactuca sativa* L., *cv*. 'Romaine'). The plants were transplanted into the pots by inserting the nursery bed materials which were mixed with rice and the horticultural seed bed (1:4 ratio) 30 days after seedling. The treatments consisted of a control represented by a pig manure compost consisting of 100% of pig manure compost pellet, and different combinations of biochar pellets, i.e., 2:8, 4:6, 8:2, and 9:1 Biochar/pig manure compost.

The pot size was Φ18 × 30 cm, and the loading amount of nursery bed was 2.25 kg per pot. The amounts of fertilizer and pig manure compost applied were 70-30-36 kg ha^{-1} (N-P-K) and

3300 kg ha^{-1}, respectively, the application amount recommended for lettuce culture. The application rate of the biochar pellet was 6.6 g pot^{-1} regardless of the mixed ratio and based on the recommended amounts of pig manure compost to be applied (3300 kg ha^{-1}) for lettuce culture. The drip irrigation was set at 2 min for irrigation period, done three times per day. The chemical properties of the nursery bed materials used are presented in Table 3. For the bioassay test, the total yield was measured during the growing period.

Table 3. Characteristics of the nursery bed materials for lettuce cultivation [1].

pH (1:5)	EC (dS m^{-1})	TC (%)	NH_4-N (mg/kg)	NO_3-N (mg/kg)
5.04	4.85	1.34	44.24	41.51

[1] EC; Electrical conductivity, TC; Total carbon.

3. Results

For released NH_4-N, it was found that the NH_4-N concentrations in all combination ratios of biochar pellet and pig manure were lower than that of the 100% pig manure compost pellet. The biochar pellet 2:8 ratio, biochar/compost displayed the highest difference compared with the pig manure compost pellet. After 150 h of retention time, not much difference could be seen between the 9:1 and the 8:2 biochar pellets (Figure 2).

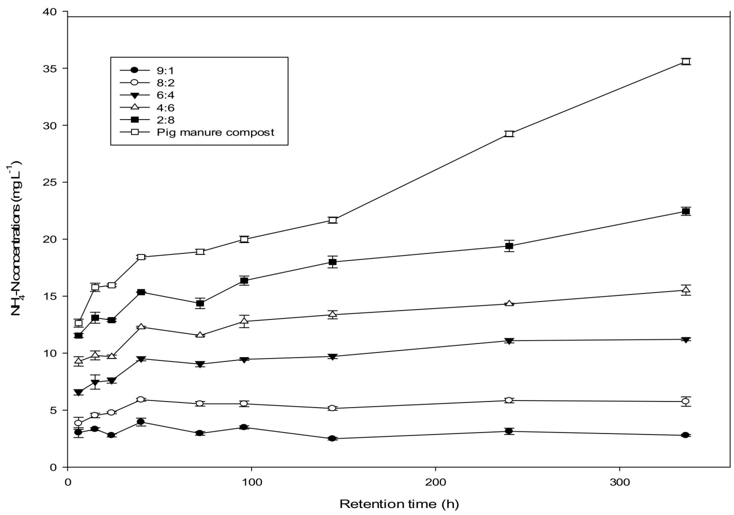

Figure 2. Changes of NH_4-N concentrations in an aqueous solution with the retention times for biochar pellets with different compositional ratios of biochar/pig manure.

Therefore, it was observed that the biochar pellet, regardless of its combination ratio, could bond NH_4-N. The adsorption amount ranged from 7.75 to 3.1 mg g^{-1}, and the removal rates decreased from 92.2 to 36.9% with decreasing biochar contents.

The results, as indicated in Figure 3, showed that increasing the quantity of the biochar content from 20 to 90% enhanced the removal rate at equilibrium and the adsorbed amount of NH_4-N into the biochar pellet. It was observed that adsorption and removal rate of NH_4-N by the biochar pellet lowered with decreasing biochar's ratios. However, it appeared that the maximum adsorption rate was observed for the 9:1 ratio of biochar pellet. The plot of Langmuir isotherm of NH_4-N absorption on the biochar pellet is presented in Figure 4. The corresponding isotherm parameters are presented in Table 5. It was observed that the Langmuir adsorption capacity of the biochar pellet for NH_4-N was 2.94 mg g^{-1}.

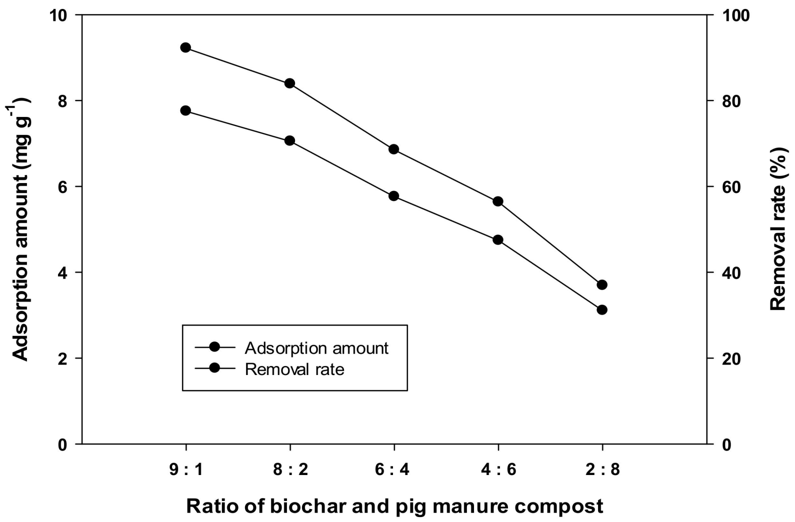

Figure 3. Variation of the adsorption amount and removal ratio of NH_4-N for different ratios of biochar pellet, with different retention times.

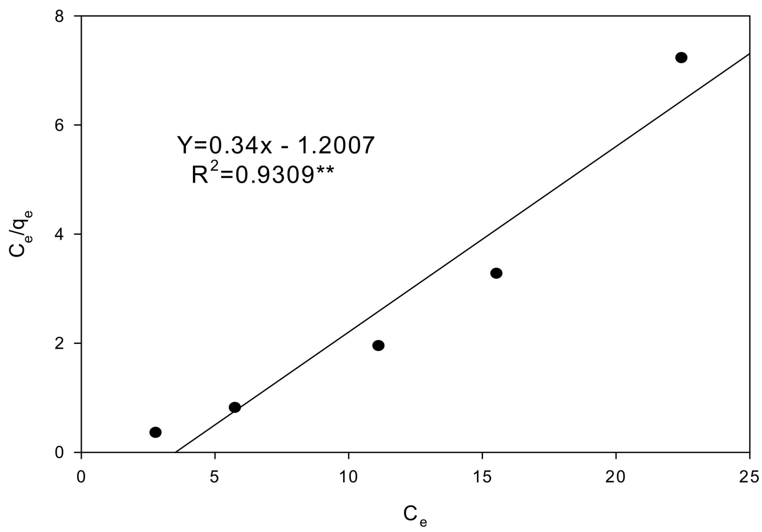

Figure 4. Langmuir isotherm plot of $1/C_e$ versus $1/q_e$ for NH_4-N (q_e is the amount of NH_4-N adsorbed on the biochar pellet (mg g^{-1}), and C_e is the concentration of NH_4-N in solution at equilibrium (mg L^{-1})).

Table 4 shows the amount of NH_4-N adsorbed at equilibrium (q_e) at the slope and intercept, rate constants (K_1 and K_2) of the kinetic models. The initial adsorbed amount (h) was calculated as seen in Figure 5. It was calculated that the constant rate (K_1) of the pseudo first-order kinetic and q_e ranged from 0.002 to 0.0019 h^{-1} and from 2.93 to 5.5 mg g^{-1}, respectively, with correlation coefficient values of 0.778–0.949. For the pseudo-second-order model, it appeared that the constant rate (K_2) and q_e ranged from 0.019 to 0.046 h^{-1} and from 2.09 to 4.65 mg g^{-1}, respectively, with correlation coefficient values of 0.986–0.991 (Table 4).

Table 4. Parameter calculated for the pseudo-first and second-order model from kinetic models.

Mixed Ratios	Pseudo-First Order			Pseudo-Second Order				[3] q_e(exp.)
	[1] K_1	[2] q_e	R^2	K_2	h	q_e	R^2	
9:1	0.0020	5.50	0.949 **	0.019	0.41	4.65	0.988 **	7.75 *
8:2	0.0020	5.12	0.932 **	0.022	0.36	4.00	0.986 **	7.05 *
6:4	0.0017	4.41	0.913 **	0.031	0.26	2.90	0.989 **	5.76
4:6	0.0018	3.97	0.851	0.046	0.19	2.02	0.991 **	4.74
2:8	0.0019	2.93	0.778	0.117	0.11	0.96	0.975 **	3.11

[1] K_1: Pseudo-first-order kinetic constant of NH_4-N, [2] q_e: Adsorption amount from pseudo-first-order equation, [3] q_e(exp): Adsorption amount from experiment data, ** denotes significance at 1.0% and * denotes significance at 5%.

The initial adsorbed amount (h) was calculated as seen in Figure 5. It appeared that the fastest adsorption of NH_4-N was for the 9:1 combination ratio of biochar pellet in the kinetic model. It was also observed that the more the biochar contained in the biochar pellet, the greater the adsorption of NH_4-N.

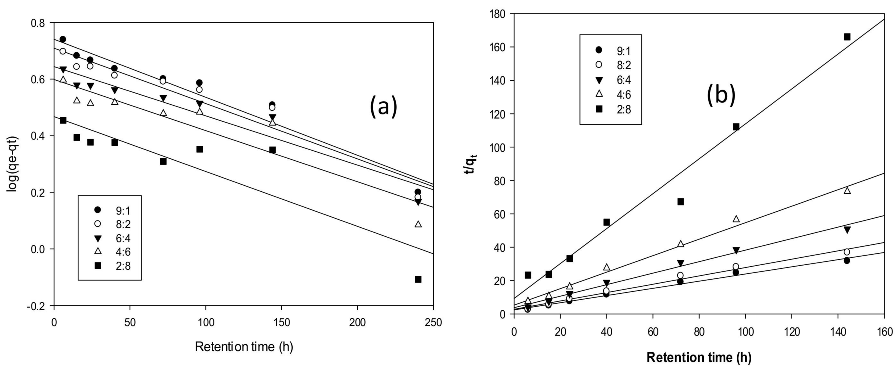

Figure 5. Pseudo-first-order kinetic plots (**a**) and pseudo-second-order kinetic plots (**b**) of NH_4-N on different ratios of biochar pellets from rice hull (q_e is the adsorption amount at equilibrium (mg g^{-1}), and q_t is the adsorption amount at time t (mg g^{-1})).

Lettuce growth responses to the application of the biochar pellets with different amounts of pig manure compost are described in Figure 6. It was observed that the leaf biomass in the 9:1 mixture-treated plots (biochar/pig manure compost) significantly increased, approximately of 13% compared with the control. The leaf biomass in plots undergoing other treatments was higher than that of the control.

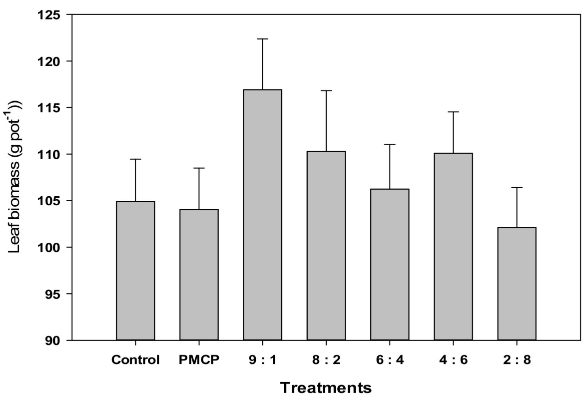

Figure 6. Growth responses of lettuce in the plots treated with biochar pellets with different ratios of biochar/pig manure compost.

4. Discussions

4.1. NH_4-N Releasing Patterns of the Biochar Pellets

The releasing patterns of NH_4-N in deionized water of biochar pellets consisting of different ratios of biochar/pig manure were investigated. As shown in Figure 1, the concentration of NH_4-N increased gradually in the combination of pellet mixed with biochar, as the retention time increased. It appeared that the binding of NH_4-N to biochar increased with the pellets' wider surface area. However, for retention times greater than 150 h, it was observed the NH_4-N concentration abruptly increased. The retention time coinciding with the maximum release was considered as the equilibrium. The releasing concentrations of NH_4-N from the biochar pellet in aqueous solution were almost constant after 250 h of retention time after equilibrium, except for the biochar pellet with a 2:8 ratio of biochar/pig manure.

4.2. Adsorption and Removal Rates of NH_4-N from the Biochar Pellets

The biochar pellet pH is well known as an important factor related to the adsorption of ions. The pH for various combination ratios of biochar ranged from pH 8.8 to 9.2 (Table 5). The biochar pellet pH increased with increasing biochar contents.

Table 5. Chemical properties of the various combination ratios of biochar pellet used.

Parameters	**2:8**	**4:6**	**6:4**	**8:2**	**9:1**
pH (1:20)	8.8	8.9	9.0	9.1	9.2
EC (dS m^{-1})	1.4	1.2	1.3	1.2	1.0

Combination ratios of biochar/pig manure compost.

The adsorption and removal rates of NH_4-N for the biochar pellet are described in Figure 2. They also increased when both biochar contents and retention time were raised. In the application of pig manure compost, 5500 kg ha^{-1} as recommended for corn culture, the releasing amount of NH_4-N was estimated at 300 kg ha^{-1} from the models (Table 2). Therefore, the adsorption amounts of NH_4-N in the biochar pellets when applied in the corn field were estimated to range from 17.0 to 42.6 kg ha^{-1}, based on the observation values and regardless of the mixing ratios of the biochar pellets. The adsorption rates of NH_4-N ranged from 5.7 to 14.2% in the corn field treated with the biochar pellets.

As for the removal rate of NH_4-N, it was the lowest at 36.9% for the pellet containing 20% of biochar, and was the highest at 92.2% for the pellet containing 90% of biochar. Regarding the dose-response relationship for the biochar, it increased with the removal rate and the adsorbed amount ($mg \cdot g^{-1}$). This could be due to the increased area of the adsorption sites, as the solid surface increases in solution [18]. Similar results of adsorption using biochar and adsorbents for NH_4-N have been described for ion-exchange resins [19], zeolites [20], and activated carbon [21]. This result implies that the biochar pellet can play an important role as an absorbent of NH_4-N when applied in cropland.

4.3. Adsorption

Two isotherm models, Freundlich and Langmuir isotherm, were tested to study the adsorption characteristics of NH_4-N on the biochar pellet. However, Freundlich isotherm was not fitted for this experiment, and, thus, the Langmuir isotherm was used. It was apparent that the Langmuir isotherm fitted the experimental data, suggesting the proper applicability of the Langmuir model to this system. Therefore, the adsorption amount of NH_4-N on the biochar pellet applied in a corn field was estimated to be 16.2 kg ha^{-1}, using Langmuir isotherm. It is considered that the adsorption rate of NH_4-N was estimated to be at 5.4% on the basis of releasing models (Table 2) in the corn field treated with the biochar pellets.

It could be estimated that the adsorption values in the treated fields could be ranged from 8 (3%) to 26.4 (8.8%) kg ha^{-1}, in case of applying the minimum and maximum Langmuir isothermal values of NH_4-N adsorption.

An R value greater than 1 indicates an unfavorable type of adsorption, while a value between 0 and 1 represents a favorable adsorption [22]. In this experiment, R^2 was 0.931, and this value indicated that the biochar pellet favors the adsorption of NH_4-N, regardless of the ratios of biochar and pig compost (Table 6).

Table 6. Parameters calculated from the Langmuir isotherm model for the biochar pellet.

q_m [1] (mg g^{-1})	b [2] (L mg^{-1})	R^2	R_L [3]
2.94	0.28	0.931 **	0.09

[1] q_m: maximum adsorption capacities of NH_4-N, [2] b: binding strength constant of NH_4-N, [3] R_L: dimensionless constant of Langmuir isotherm, ** denotes significance at 1.0% levels.

4.4. Adsorption Kinetics

Similar to the batch test, a kinetic experiment using 211.5 mg of biochar pellet in 50 mL of deionized water was performed. The sorption of ammonium nitrogen was investigated for five combination ratios of biochar pellet, i.e., 9:1, 8:2, 4:6, and 2: 8, at 25 °C and with aretention time ranging from 0.5 h to 250 h. The consistency between the measured data and the predicted values from the model was expressed by the correlation coefficient r^2. The relatively higher value is more applicable to the kinetics of NH_4-N adsorption. The best selected kinetic models are based on both the coefficient (r^2) of linear regression and the calculated q_e values. When the calculated q_e (mg·g^{-1}) was compared to the measured value (q_e(exp)), it was decided that, if the calculated q_e was close in the range to the measuring value (q_e(exp)), the data fitted well. Another judgement was considered for the coefficient value of regression (R^2). The isotherm curves for each model are described in Figure 4. It was calculated that the constant rate (K_1) of the pseudo-first-order kinetic and q_e ranged from 0.002 to 0.0019 h^{-1} and from 2.93 to 5.5 mg g^{-1}, respectively, with correlation coefficient values of 0.778–0.949. For the pseudo-second-order model, it appeared that the constant rate (K_2) and q_e ranged from 0.019 to 0.046 h^{-1} and from 2.09 to 4.65 mg g^{-1}, respectively, with correlation coefficient values of 0.986–0.991. The initial adsorbed amounts (h) ranged from 0.11 to 0.41 mg g^{-1} min^{-1}. It was found that the correlation coefficient values (R^2) for the pseudo-second-order models were higher than those for the pseudo-first-order model for the different biochar combination ratios. It can be assumed that some of the NH_4-N adsorption in the biochar pellet could occur by chemisorption, with a better fit for the pseudo-second-order model [23].

4.5. Plant Growth Responses to the Biochar Pellets

The application of biochar pellets regardless of the biochar contents for lettuce cultivation could sequester soil carbon and mitigate the greenhouse gases without reduction of lettuce yield compared with the control plots treated with pig manure compost only. The lettuce yield in plots treated with biochar pellet that contained at least 40% biochar was higher than that of the control. It was considered that this might be due to the binding of NH_4-N to biochar followed by slow releases during lettuce growth. However, these results need further study to explain why lettuce yields in the two treatments abruptly increased. Moreover, the application of biochar in the corn field for carbon sequestration did not inhibit corn growth, rather it increased the fresh weight of corn biomass, except for the application of pig manure compost [24]. Shin et al. [25] indicated that there was not a significant difference on plant height and fresh ear yield among the biochar treatments.

5. Conclusions

It is necessary to study the adsorption characteristics of NH_4-N on combinations of biochar pellet containing different amounts of pig manure compost with respect to carbon sequestration, for farming practices. The maximum adsorption rate observed was for the 9:1 ratio of biochar pellet/pig manure. For the removal rates of NH_4-N, the lowest rate at 36.9% was found for the pellet containing 20% of biochar, and the highest at 92.2% for the pellet containing 90% of biochar. The Langmuir adsorption capacity of the biochar pellet for NH_4-N was 2.94 mg g^{-1}. The fastest absorption of NH_4-N was observed for the 9:1 combination of biochar pellet, as determined by kinetic models. It was observed that the higher the amount of biochar contained in the biochar pellet, the greater the adsorption of NH_4-N. The correlation coefficient values (R^2) for the pseudo-second-order model were higher than those of the pseudo-first-order model for different biochar combination ratios. For the plant responses, it was observed that leaf biomass in 9:1 biochar/pig manure-treated plots increased more, by approximately at 13%, compared with those in the control. In addition, the leaf biomass of other treatments was also higher than that of the control. This implies that the application of biochar pellet, regardless of the biochar content, is potentially useful to obtain fundamental data for NH_4-N adsorption in in agricultural practices.

Author Contributions: J.S. conceived and designed the study. J.S., E.C., E.J., S.G.H., B.R., S.L. compiled the numerical tables and graphs and completed the writing of this paper. Finally, the writing was reviewed by J.S., B.R. All authors read and approved the manuscript.

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