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Original paper

Effects of Biochar Pellet Application on the Growth of Pepper for Development of Carbon Sequestration Technology in Agricultural Practice

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토양 탄소 격리 기술 개발을 위한 바이오차 팰렛 시용에 따른 고추 생육 효과

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ABSTRACT: Objective of this experiment was to evaluate the effect on pepper growth to application of biochar pellet in case of development of soil carbon sequestration technology. The treatments consisted of control as a general agricultural practice method, pellet (100% pig compost), biochar pellets with mixture ratio of pig compost (9:1, 8:2, 6:4, 4:6, 2:8) for comparison of total carbon contents, NH_4-N concentrations, and total biomass in the pots applied with biochar pellets after pepper harvesting. The application rates of biochar pellet was 8.8 g/pot regardless of their mixed rates based on recommended amount of application (440 kg/10a) for pepper cultivation. For the experimental results, Total carbon contents in the treatments were low from 1.8 to 2.6 fold as compared to the control. NH_4-N concentrations were not significantly different among the treatment plots as compared to the control, but NO_3-N was not detected in the all treatment plots. However, total biomass was not only significantly different between the control and 2:8 (biochar : pig compost) biochar pellet application plot even if the other treatments were low. Therefore, this biochar pellet application might be further modified for soil carbon sequestration in agricultural farming practices.

Keywords: Biochar pellet, carbon sequestration, growth responses, pepper

초 록: 본 실험의 목적은 토양탄소 격리 기술을 개발하기 위한 바이오차 팰렛 시용에 따른 고추 생육 효과를 평가하는 것이다. 처리는 고추 수확 후 총 탄소 함량, 암모늄태 질소의 농도 및 총 바이오매스량 비교를 위해 일반적인 영농 방법으로서 대조구, 돈분 팰렛, 바이오차와 돈분 퇴비 혼합 비율별 바이오차 팰렛 시용구 (9:1, 8:2, 6:4, 4:6, 2:8)로서 구성되어 있다. 바이오차 팰렛의 사용량은 고추 재배를 위한 추천 시용량 (440 kg/10a)기준으로 혼합 비율에 관계없이 8.8 g/pot이었다. 실험 결과로서 총 탄소 함량은 대조구와 비교하여 처

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리구에서 1.8-2.6배 낮게 나타났다. 암모늄태 질소의 농도는 대조구와 비교하여 처리구들 사이에 유의차가 인정되지 않았으며, 질산태 질소는 모든 처리구에서 검출되지 않았다. 그렇지만, 총 바이오매스량은 다른 처리구에서는 낮게 나타났다 할지라도 대조구와 2:8 바이오차 팰렛 처리구 사이에는 유의차가 인정되지 않았다. 따라서 이 바이오차 팰렛 시용은 농사 활동에 있어서 탄소격리를 위해서는 더욱더 연구되어야 한다.

주제어: 바이오차 팰렛, 고추, 생육 반응, 탄소격리

1. Introduction

Biomass is composed of carbon rich materials including all plants, animals, nutrients, excrements and bio-waste from households and industries[1]. Unused or discarded biomass residues from agricultural areas are potential energy resource, but at same time can be a source of greenhouse gases(GHG) emissions, causing a significant environmental problem. Potential energy production from crop and animal residues is globally estimated to be about 34 EJ (exajoule $=10^{18}$ joules) out of a total 70EJ[2]. In Korea, it is estimated that over 50 million tones of organic wastes are produced every year in agricultural sector out of over 80 million tones[3]. The interest of biomass in resource-poor country such as Korea is therefore increasing.

Biochar is the carbonaceous product obtained by heat treatment of biomass under limited or no oxygen (pyrolysis or liquefaction technology). Biochar has recently gained attention for its potential, when cooperated with soil to improve soil fertility and to store carbon removed from the atmosphere by plants. Biochar's positive effects on the soil ecosystem, including both plants and microbes, have been proposed to derive either directly from nutrients within biochar itself or indirectly its ability to absorb and retain nutrients [4), 5)].

Soil plays significant roles in global carbon cycle. It was estimated that soils have contributed as much as 55 to 878 billion tons (GT) of carbon to the total atmospheric CO_2[6]. The total soil carbon consists of the soil organic and inorganic carbons, estimated to be approximately over 2250 GT in the top 1 meter depth[7]. Biochar may improve soil chemical properties as increase of soil pH and cation exchange capacity (CEC), and enhancement of nutrient retention. The reduction in N_2O emissions after biochar soil amendment was first reported in a greenhouse experiment by Rondon *et al.*[8]. They found that N_2O emissions were decreased by up to 50% for soybean and by up to 80% for grass growing in a low fertility oxisol from the Colombian savanna. Since then, the interest in bio-char as a N_2O mitigation strategy for agricultural soils has been continuously increasing, and the number of studies evaluating N_2O emissions from biochar treated soils has risen exponentially.

Carbon inputs and outputs are affected by management and by two biotic processes- production of organic matter in the soil and decomposition of organic matter by soil organism. The soil carbon sequestration by biochar application is determined by the soil carbon residual differences between compost treatments only and cooperated with biochar after harvesting corn. For effect of biochar application, it found that applications of

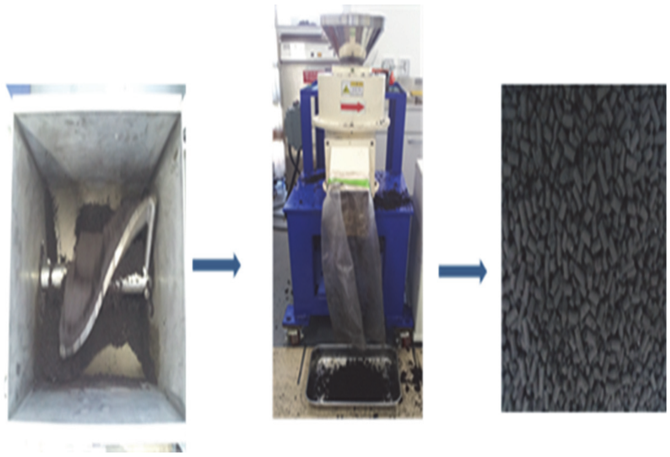

Photo 1. Paradigms of processing the biochar pellets for this experiment

aerobic swine digestate, cow compost, and pig compost could sequester C by 38.9%, 82.2% and 19.7% in soil, respectively, when biochar from rice hulls was cooperated with soil[9]. However, there is litter information available on biochar pellet that can control nutrient release rate from pellet to soil throughout the growing season and to provide most of nutrients to plant without leaching loss[10].

Therefore, this study was conducted to evaluate growth responses of pepper and physicochemical properties of soil to biochar pellet application in case of soil carbon sequestration for agricultural practices.

2. Materials and Methods

Biochar pellet made through the machine with those combination materials which were completely mixed with instrument [Photo 1]. The combination ratios of biochar and pig compost were 9:1, 8:2, 6:4, 4:6 and 2:8. Treatments were consisted of control, 100% of pig compost pellet, and biochar pellets with mixture ratio of pig compost; 9:1, 8:2, 6:4, 4:6 and 2:8.

For plant growth responses to application of biochar pellets, the seed was sowed in the nursery plate with inserting pit moss in the glass house at January 4, 2016. The crop was pepper, and the plants were transplanted into pots inserting fine clay soil at 30 days after seedling. The pot size was Φ18×30 cm, and loading amount of soil was 2.25 kg per each pot. Application amount of fertilizer and compost were based on 0.53-0.61-0.2 g(N-P-K)/pot and 8.8 g pot^{-1} as recommended application amount for pepper cultivation. The dropping irrigation was set on 2 min. for one time irrigation period with 3 times per days. Chemical properties of soil used in this study were presented in [Table 1].

Table 1. Physicochemical properties of soil before experiment

pH	EC	TC	TOC	TN	C/N ratio	NO_3-N	NH_4-N
(1 : 5)	dS m^{-1}	-------%	---------			mg kg^{-1}	mg kg^{-1}
7.0	0.63	0.98	0.86	0.09	10.6	8.11	7.37

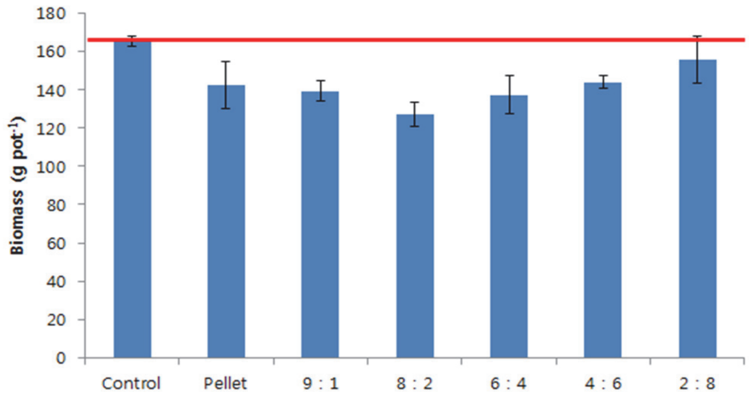

Fig. 1. Comparisons of total biomass of pepper in the pots incorporated with biochar pellets with different ratios of pig compost mixed after pepper harvesting.

Soil samples were collected after harvest of pepper. The samples were dried and passed through 2 mm sieve and then stored in refrigerator (4℃) until analyzing the soil chemical properties.

Analytical soil chemical properties were total nitrogen (TN), total carbon (TC), total organic carbon (TOC) and total inorganic carbon (TIC) by TOC analyzer (Elementar Vario EL II, Germany). Total carbon combustion temperatures was 950℃ and WO_3 was used as the catalyst. The carbonate was destroyed completely by using 2M HCl until there were no bubbles and fumes, and then samples were dried for another analysis. Thus TOC content was obtained. TIC was determined by the difference between TC and TOC. Soil extract solutions with 2M KCl (1:5, soil: extractant ratio) were analyzed NH_4-N and NO_3-N contents by Auto Analyzer Technician II. For the plant responses, total biomass was measured at harvesting time.

3. Result and Discussions

Growth responses of pepper in the pots to application of biochar pellet with different combination rates of pig compost were described in [Fig. 1]. It was observed that total biomass in both 2:8 treatment plot (biochar: pig compost) was not significantly different with the control which was applied pig compost. Total biomass of the other treatments were litter lower than the control. This implies that application of biochar pellet which is 20% of biochar content for pepper cultivation should be sequestered soil carbon and mitigated the greenhouse gases without reduction of pepper biomass compared with the control. This results need to be more elucidated why pepper ‘s biomass in this treatment have not been different in the future study. Also, application of biochar in the corn field for carbon sequestration was significantly not occurred the damage of corn growth and enhanced the fresh biomass weight of corn except PC (pig compost) treatment[9]. Shin et al. indicated that plant height and fresh ear yield of corn were not significantly different among the biochar treatments[11].

TC contents in soil applied biochar pellets with different ratios of biochar mixed after pepper harvesting were described in [Fig. 2].

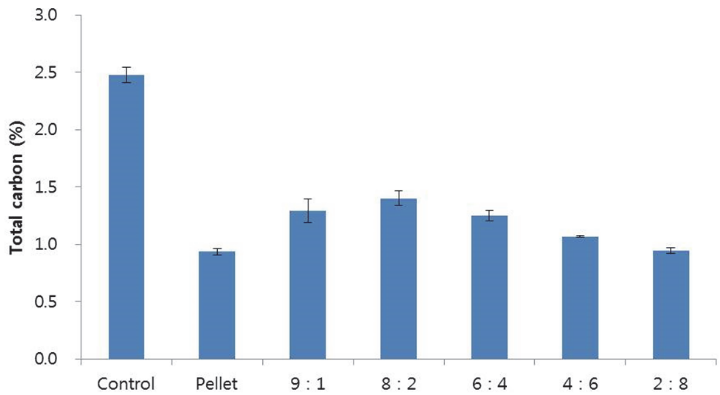

Fig. 2. Comparisons of total carbon in soil applied with biochar pellets with different ratios of pig compost mixed after pepper harvesting.

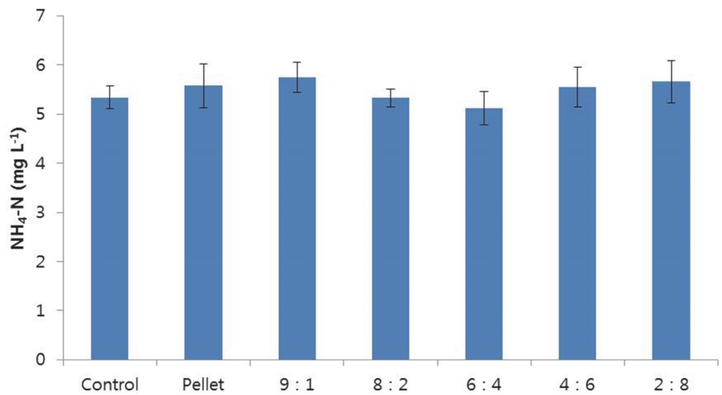

Fig. 3. Comparisons of NH_4-N concentrations in soil applied with biochar pellets with different ratios of pig compost mixed after pepper harvesting.

TC of pellet was higher at 2.5 times than the control which was applied pig compost. However, there were not significantly different over 60% of biochar mixed pellets, and then decreased with lower biochar mixed ratio. Even if TC in the control remained high in soil after harvest, it is imply that this is not stored in soil carbon because of easily decomposing the organic matter, and of not continuously sequestered soil carbon[12]. It is possibility that pellets mixed with biochar are able to sequester soil carbon after harvesting pepper in agricultural practice.

Patterns of NH_4−N concentrations in the soil applied biochar pellets after harvesting were described in [Fig. 3]. NH_4−N concentrations in the soil applied biochar pellets were not significantly different among treatments relative to the control. It implied that nitrogen nutrient may not be lacked for pepper cultivation even if put small quantity of pig compost into the pot.

Summary

For the experimental results, total carbon contents in the treatments were low from 1.8 to 2.6 fold as compared to the control. NH_4−N concentrations were not significantly different

among the treatment plots as compared to the control, but NO_3−N concentrations were not detected among the treatment plots. However, total biomass was not significantly different between the control and 2:8 (biochar : pig compost) biochar pellet application plot even if the other treatments were low.

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