Effect of Rice Bran and Wood Charcoal on Soil Properties and Yield of Continuous Cropping of Red Pepper

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Key words: physical property, rice bran, soil microbial communities, wood charcoal

Abstract

To improve the soil properties of physical and microbial community rice bran and wood charcoal were applied in the continuously cultivated plastic film house soil. Soil physical properties were improved by application of rice bran and charcoal compared to chemical fertilizer application (control) by 8~14% in bulk density and 5~9% in soil porosity. Changes in the biological ratio indexes of fatty acids in the soils were detected depending on the inputted materials. Especially in application of rice bran including mixture with charcoal, much more fungi and less bacteria were detected and the ratio of fungi to bacteria was increased, suggesting the more organic carbon metabolically active in these treatments. The high ratio of aerobe to anaerobe suggested the better aerobic conditions were in the soil inputted wood charcoal. From these results, it is important and possible to select some materials for the organic pepper cultivation, which may improve the poor condition soil.

Introduction

According to a definition of organic agriculture proposed by Codex Alimentarius commission, organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity (CODEX 1999). General characteristics of vegetable replanting problems appeared to be decrease on red pepper yields due to injuries of continuous cultivation of single crop in plastic film house soil (Jeong *et al.* 2005). Salinity problems are caused from accumulation of soluble salts in the soil. These excess salts reduce plant growth and vigour by altering water uptake and causing ion-specific toxicities or imbalance (Kim & Chung 2005). Therefore it is very practical to cultivate green manure crop or to input some environment friendly matters for reducing the injuries of continuous cultivation same crops. Red hot pepper is one of the most important vegetable crops for seasoning food in Korea. Therefore, this study was carried out to improve the soil properties of physical and microbial community by application of eco-friendly or organic materials like rice bran and wood charcoal in the continuously cultivated plastic film house soil.

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Materials and methods

This study was carried out to investigate the effect of application of rice bran and wood charcoal on assessing the physical and microbial properties in continuously red pepper cultivated plastic film house soil. A randomized block design was used with three replications and individual plots were approximately 20 ㎡ (2 X 10m) for this research. At first, each plot was applied with compost 10 ton per ha except the control. After that the plots were treated with rice bran 10 ton per ha, woody charcoal powder 2 ton per ha and rice bran + woody charcoal. In control, only chemical fertilizer were treated with N: P: K = 190:112:149 kg per ha. On April 10, 'Superbigarim' variety seedlings were transplanted in 100 cm rows. The red peppers were harvested three times and the fruit characteristics were investigated. Soils were sampled to a depth of 10 cm with a soil probe (diameter: 5 cm) at three points in each plot after the red pepper seedlings were transplanted. The sampled soils were dried at shady place and passed through a 2-mm mesh sieve and stored within closed plastic bags at -80℃ in the dark until analysis. Microbe populations were analyzed by phospholipid fatty acid (PLFA) method (Feng 2003). In brief, lipids were extracted from soils by a one-phase chloroform, methanol and water extractant, and then fractionated into neutral lipids, glycolipids and phospholipids on a silicic acid column. The phospholipids were then subjected to alkaline methanolysis and analysis on a gas chromatograph with a flame ionization detector. Statistical analysis of data was carried out using SAS and to determine the significance among the means of treatments, LSD was computed at the 5 % probability level.

Results

Soil physical properties were investigated after inputting rice bran and wood charcoal (Table 1). Bulk density and porosity of soil were 1.03 g m^{-3} and 61.1 % in control and 0.89~0.95 g m^{-3} and 66.3~64.6 % in others treatments. Among the three phases of soil, solid phase was reduced and gaseous phase was increased in rice bran and charcoal inputted soil compared to control soil.

Tab. 1: Changes of soil physical properties and three phases as affected by application of rice bran, woody charcoal and conventional chemical fertilizer (control) in continuous cultivated soil of red pepper in plastic film house

Treatments	Bulk density (g cm^{-3})	Soil porosity (%)	Three phases of soil (%)		
			Solid	Liquid	Gaseous
Rice bran	0.89±0.05	66.3±1.8	33.7±1.8	24.8±0.4	41.5±1.9
Woody charcoal	0.94±0.01	64.6±0.4	35.4±0.4	24.9±3.0	39.7±3.4
Rice bran + charcoal	0.95±005	64.1±1.9	35.9±1.9	24.4±1.6	39.7±0.4
Control	1.03±0.03	61.1±1.2	38.9±1.2	23.3±1.0	37.8±0.6

* Values are means±SD

In the soil microbe populations analyzed by PLFA, it was different among the four material applications (Figure 1). Fungi groups were increased in the soil inputted with rice bran and mixture of rice bran and charcoal. On the other hand, bacteria and actinomycetes groups were increased in the soil inputted with wood charcoal and

chemical fertilizer. VAM-fungi group was increased just only in woody charcoal application. In changes in the biological ratio indexes of fatty acids in the soils, the ratio of Gram-negative to Gram-positive bacterial PLFA was increased in rice bran and mixture of rice bran and charcoal. Ratio of aerobes to anaerobes was high in woody charcoal and mixture of rice bran and charcoal. It suggested that more aerobic soil conditions were made by inputting woody charcoal into the soil. The ratio of saturated to unsaturated fatty acids and cycloprophyl to precursor showed the same tendency that those ratios were higher in control than other treatments. The ratio of fungi to bacteria was also high in the application of rice bran and mixture of rice bran and charcoal.

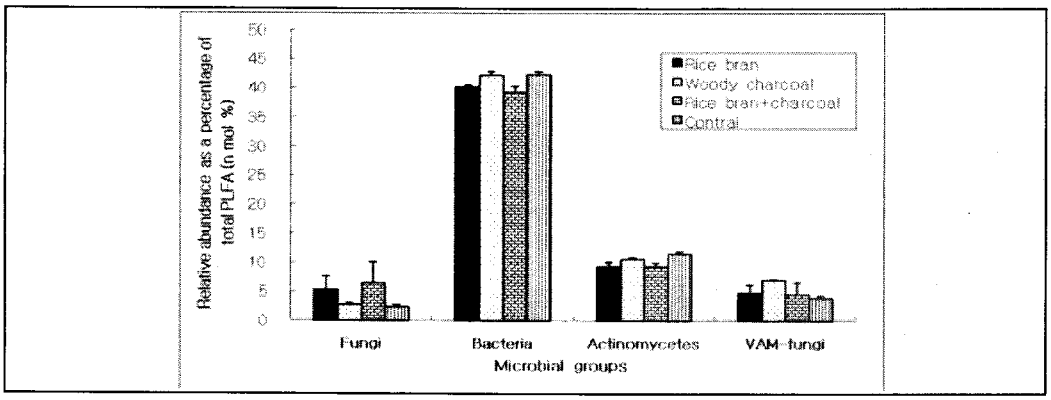

Figure 1: The class of fatty acids on the soils amended with four different treatments. The vertical bars indicate the standard deviation of the means.

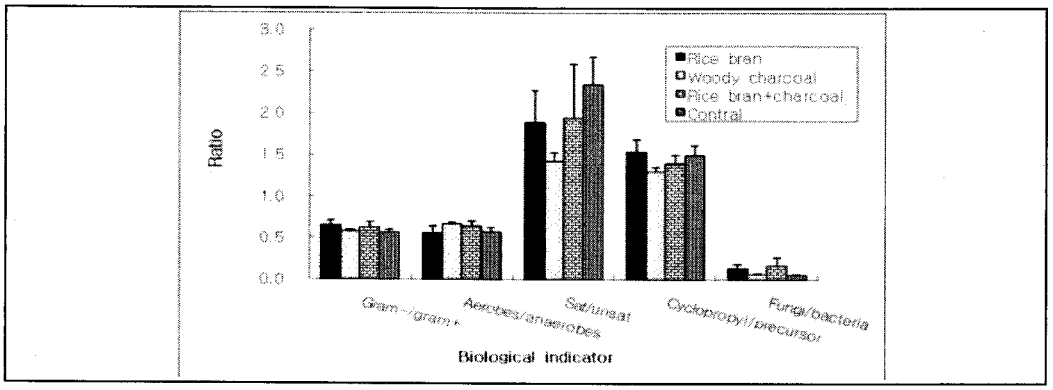

Figure 2: Changes in the biological ratio indexes of fatty acids in the soils amended with four different treatments. The vertical bars indicate the standard deviation of the means.

Due to the improvement of soil physical properties and the microbial communities, the pepper plant growth and yield were somewhat influenced. Fresh weight and fruit number of red pepper were higher in application of mixture of rice bran and charcoal as 993 g and 59.1 per plant (Table 2). But those of control were 914 g and 50.1 per plant. Finally the yields of dried red pepper were 5.72 in application of mixture of rice bran and charcoal and 5.16 ton per ha in control.

Tab. 2: Yield (t ha^{-1}) and fruit characteristic of red pepper as affected by application of rice bran, woody charcoal and conventional chemical fertilizer (control) in continuous cultivated soil of red pepper in plastic film house

Treatments	Fresh W. (g plant^{-1})	Fruit number (no. plant^{-1})	Fresh W. (g fruit^{-1})	Dry W. (g fruit^{-1})	Yield (t ha^{-1})
Rice bran	923±34	56.5±6.9	20.4±3.4	4.3±0.3	5.38±0.5
Woody charcoal	888±30	53.7±3.5	21.2±1.9	4.4±0.1	5.09±0.2
Rice bran + charcoal	993±74	59.1±4.9	21.7±0.9	4.5±0.1	5.72±0.2
Control	914±85	50.1±4.8	22.1±0.5	4.5±0.2	5.16±0.4

* Values are means±SD

Discussion

Researchers have reported that the soil physical and chemical properties of the continuous red pepper cropping field were dramatically improved with incorporation of rice bran, wheat bran and wood charcoal. In present study, we investigated that not only the effects of soil properties but also changes of microbial communities in soils amended with organic amendments. The bulk density and porosity of soil were improved by application of rice bran and charcoal as reported by Kim *et al.* (2006) and Park *et al.* (2003). Kim *et al.* (2006) reported that the improving of hydraulic conductivity and water stable aggregation by organic materials influenced the soil physical properties. Changed biological ratio index of fatty acids in the soils were detected depending on the inputted materials. Especially in application of rice bran including mixture with charcoal, the ratio of fungi to bacteria increased, suggesting the more organic carbon metabolically decomposed under these treatments. The high ratio Gram-negative to Gram-positive also suggest more nutrition for microbes in rice bran inputted soil. The high ratio of aerobe to anaerobe suggested the better aerobic conditions in wood charcoal inputted soils. The dried red pepper yield was the highest in application of mixture of rice bran and wood charcoal.

References

CODEX Alimentarius Commission (1999): Guidelines for the production, processing, labelling, and marketing of organically produced foods. FAO, Rome, Italy.

Feng Y., Motta A.C., Reeves D.W., Burmester C.H., van Santen E., Osborme J.A. (2003): Soil micro microbial communities under conventional-till and no-till continuous cotton systems. Soil Bilolgy & Biochemistry. 35:1693-1703.

Jeong H.S., Kim S.W., Kim Y.J., Kim E.J., Min J.S., Yang J.E., Ok Y.S., kim Y.B., Lee Y.S. (2005): Changes of soil microbe populations in the plastic film house soils showing a disorder due to the continuous cultivation of single crop. J. Agr. Sci. 16:115-124.

Kim J.W., Chung J.B. (2005): Green pepper cultivation in mixture bed of soil and rice hull for alleviation of salinity problems in plastic film house. Korean J. Soil Sci. Fert. 38:340-344.

Kim S.H., Lee S.M., Lee Y.J., Kim H.M., Son S.Y., Song B.H. (2003): Effects of charcoal powder on the growth and development of red pepper and the changes of soil microflora. Korean J. Organic Agriculture 11:55-64.

Kim H.L., Sohn B.K., Jung K.H., Kang Y.K. (2006): The effect of anaerobic fermentation treatment of rice or wheat bran on the physical and chemical property of plastic film house soil. Korean J. Soil Sci. Fert. 39:366-371.