Research article

Effects of Adding *Bacillus* sp. on Crop Residue Composting and Enhancing Compost Quality

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Received 21 December 2012 Accepted 10 June 2013 (*Corresponding Author)

Abstract Local farmers tend to burn crop residues to simplify soil preparation for the following season cultivation. Along with the environmental conservation policies that were implemented by the government, local farmers began to consider the adverse effects of crop residue burning. In this regard, efficient utilization of organic resources through composting of crop residues has been practiced. The objectives of this study were to find out the effects of adding *Bacillus* sp. on composting of crop residues and to observe the effects of *Bacillus* sp. added crop residues on plant growth. The number of *Bacillus* sp. colonies existing in crop residue and soil were determined by agar culture medium. Composting was carried out based on the number of Bacillus Bacterial colonies (cfu): 1.5×10^{14}, 1.5×10^{16} or 1.5×10^{18} cfu. Carbon-to-nitrogen (C/N) ratio and number of *Bacillus Bacteria* were measured once a week. To observe the effects of *Bacillus* sp. added compost on plant growth, pots were prepared as control pots; crop residue pots; *Bacillus* sp. added crop residue pots; and burned crop residue pots. Komatsuna (*Brassica rapa*) were cultivated. Based on the experimental results, it was found that compost with higher number of *Bacillus* sp. have significant decrease of C/N ratio with time. Also, it was found that the mass of the crops in the pots added with *Bacillus* sp. (average 1.4 g) was larger than that control pots (0.5 g). Therefore, adding of *Bacillus* sp. can promote decomposition of crop residues and enhance the quality of compost.

Keywords *Bacillus* sp. growth, C/N ratio, crop residues compost

INTRODUCTION

Burning of crop residues influenced the degradation of soil ecosystem and its quality (Srimuang et al., 2004). Therefore, treating of crop residues such as composting, for bio-fertilizer on crop is strongly recommended (Li et al., 2012). Compost, a kind of organic fertilizer made from crop residues, is an effective material for improving physical and chemical properties of soil. The important factors to enhance decomposition are moisture, air and microorganisms. (Mihara et al., 2009). At rural areas, manure has become the source of microorganisms for compost. But with increment in the rural development, family livestock industry has reduced. Therefore, crop residue compost by manure is difficult to be sustained in the rural areas. Although there were many reports on the effect of adding organic matter on the crop residue composting, few studies have added *Bacillus* sp. on decomposition. Therefore this study has been proposed. The objectives of this study are 1) to find out the effects of adding *Bacillus* sp. on composting of crop residues and 2) to observe the effects of *Bacillus* sp. added crop residues on plant growth.

METHODOLOGY

To extract from corn residue, *Bacillus Bacterial* was cultured for 3 days in the incubator. This is the *Bacillus* sp. in liquid used for the experiment. The number of *Bacillus* sp. colonies existing was determined by agar culture medium. The concentration of *Bacillus* sp. liquid was 6×10^{15} cfu/ml (colony-forming units per milliliter). Dilution of the *Bacillus* sp. liquid was made in different concentrations of 6×10^{11} cfu/ml, 6×10^{13} cfu/ml, 6×10^{15} cfu/ml with crop residue compost (Fig. 1).

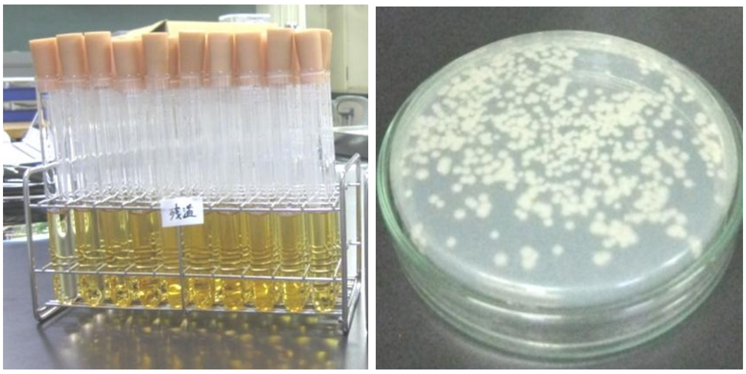


Fig. 1 *Bacillus* sp. liquid made by corn residue

The different concentrations of *Bacillus* sp. at 250 ml was added to the finely cut dry corn residues at 50 g in a tray (L186 mm, W147 mm, and H47 mm). The different concentrations sprinkled were control tray (no cfu added), 1.5×10^{14} cfu added tray (same cfu of 50 g residues), 1.5×10^{16} cfu added tray (100 times more than cfu of 50 g residues) and 1.5×10^{18} cfu added tray (10000 times more than cfu of 50 g residues) at tray (Table 1). Period of composting was from August 3rd to August 31st, temperature of the experiment was about 25 degrees Celsius to 37 degrees Celsius in Tokyo (Japan). 50 ml of water was sprinkled once every 3 days, and samples were stirred after that (Fig. 2). The experiment data was collected once a week. Samples of different concentrations were subjected to carbon-to-nitrogen (C/N) ratio analysis, to understand the effects of adding *Bacillus* sp. on crop residue composting processes. Following that, the number of *Bacillus Bacteria* was measured after water was sprinkled.

Table 1 Number of *Bacillus Bacterial* cfu at corn residues and *Bacillus* sp. liquid

Corn residues	*Bacillus* sp. liquid I	*Bacillus* sp. liquid II	*Bacillus* sp. liquid III
3×10^{12} cfu/g	6×10^{11} cfu/ml	6×10^{13} cfu/ml	6×10^{15} cfu/ml
1.5×10^{14} cfu/50g	1.5×10^{14} cfu/250ml	1.5×10^{16} cfu/250ml	1.5×10^{18} cfu/250ml

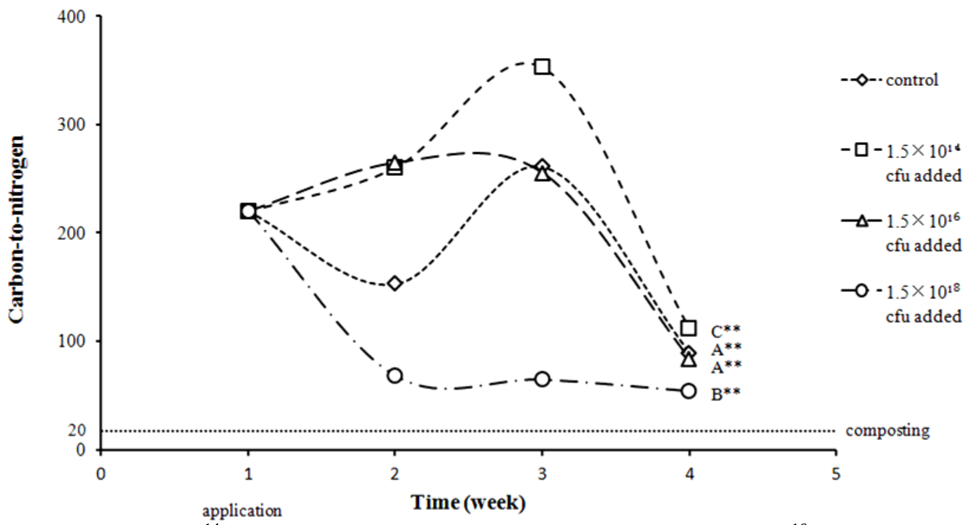
Fig. 2 Crop residue compost in laboratory of Japan

Meanwhile, in the growth experiment; 20 pots were prepared (unit area is 1/10000 a, and a height of 150 mm), and was divided into four experimental pots. In control pots, 900 g of soil was put into 5 pots. In residue added pots, 900 g of soil and 12.2 g dry corn residue was put into 5 pots. In *Bacillus* sp. added pots, 900 g of soil, 12.2 g dry corn residue and 61 ml *Bacillus* sp. liquid (6×10^{15} cfu/ml) was put into 5 pots. In ash of residues added pots, 900 g of soil and ash of 12.2 g dry corn residue was put into 5 pots. Kamatsuna (*Brassica rapa*) were cultivated (Fig. 3). The growing period was from August 10th 2012 to September 7th 2012, temperature during the experiment was about 25 degrees Celsius to 37 degrees Celsius in Tokyo (Japan); 100 ml of water was sprinkled once every 3 days; and length of growth was obtained after the water was sprinkled. And at the final experiment, weight of growth was measured in laboratory.

Fig. 3 Crop growth in laboratory

RESULTS AND DISCUSSION

In the crop residue composting of sprinkled *Bacillus* sp. experiment with 1.5×10^{18} cfu added tray crop residue, it presented decomposition closer to compost maturity over the others concentrations of *Bacillus* sp. liquid added tray. The carbon-to-nitrogen data showed that 1.5×10^{18} cfu added tray has a tendency to decrease throughout all of the experiment; meanwhile the other tray showed increment at 3 weeks times followed with continuous decrease pattern (Fig. 4). Initially, rise in the carbon-to-nitrogen ratio were observed due to the growth of the added microorganisms and their consumption of nitrogen. After that, in order to decompose organic matter, microorganisms absorb from raw material. Once the decomposition process started the microorganisms populations continually increase to the maximum population level. Having reached maximum population, the C/N ratio decreases to the conversion with the normal composting line where there is no more decomposition (Nishio, 2009) is possible.



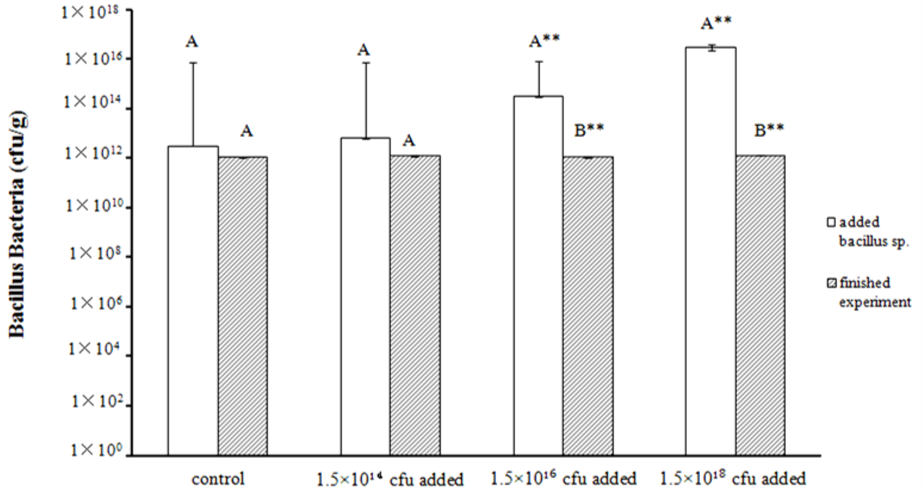
control (no cfu added), 1.5×10^{14} cfu added (same cfu of 50 g corn residues added), 1.5×10^{16} cfu added (100 times more than cfu of 50 g corn residues added), 1.5×10^{18} cfu added (10,000 times more than cfu of 50 g corn residues added)

Fig. 4 Changes in carbon-to-nitrogen with difference concentration of *Bacillus* sp. added

In finished crop residue compost, the number of *Bacillus Bacterial* colonies returned to the same number of that preceding the addition of *Bacillus* sp (Fig. 5). Therefore, the added *Bacillus* sp. was used as a nutrient during the composting experiment.

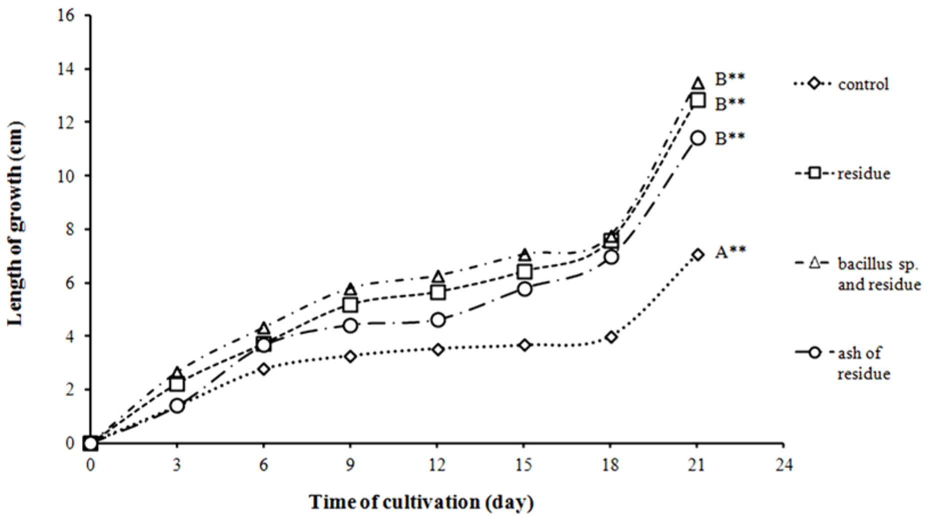
Besides that, in this experiment, the effect of *Bacillus* sp. added into crops can be observed by comparing the height of crop growth. It was found that crops grown in pots added with *Bacillus* sp. have grown 2.8 times higher (1.4 cm) than that of control pots (0.5 cm). A significant difference at

99% was also observed. Although the crop grown in pots added with *Bacillus* sp. is higher than residue pots and ash of residue pots, there is no significant difference observed by the method of dispersion ratio (Fig. 6). The experiment result shows the crop grown with residue grows much better than the crop grows without residues because the residue is rich in nutrients (Zhong et. al 2003).



control (no cfu added), 1.5 $\times 10^{14}$ cfu added (same cfu of 50 g corn residues added), 1.5 $\times 10^{16}$ cfu added (100 times more than cfu of 50 g corn residues added), 1.5 $\times 10^{18}$ cfu added (10,000 times more than cfu of 50 g corn residues added)

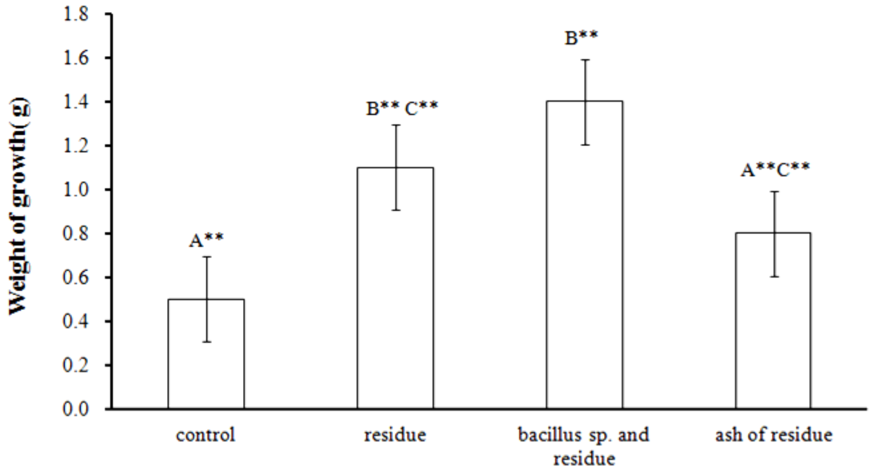
Fig. 5 Change in quantity of *Bacillus* sp. before and after the experiment



control (only put soil in pots), residue (put residues and soil in pots), bacillus sp. and residue (put bacillus sp., residues and soil in pots), ash of residue(put ash and soil in pots)

Fig. 6 Height of crop in growth experiment

The effect of *Bacillus* sp. added compost into crops can be observed by comparing the weight of crop growth. It was found out that crop grown in *Bacillus* sp. added into pots have 2.5 times higher (1.5 g) than control sample (0.6 g). Furthermore, the crop grown in *Bacillus* sp. was 1.9 times heavier than crop grown in ash of residue in Fig.7. A confidence interval at 99% was also observed. Moreover, the order of experiment results which is more environmental friendly way to grow the crop is: adding *Bacillus* sp. > adding residue > adding ash of residue > control. Therefore, based on the result of the experiment, mixing *Bacillus* sp. liquid with mulching crop residues is the best way to improve crop growth compared to burning crop residues in the farmland.



control (only put soil in pots), residue (put residues and soil in pots), bacillus sp. and residue (put bacillus sp., residues and soil in pots), ash of residue(put ash and soil in pots)

Fig. 7 Weight of crop in growth experiment

CONCLUSION

Crop residue composting of sprinkled *Bacillus* sp. experiment found that in the 1.5×10^{18} cfu added tray crop residue decomposition was closer to compost maturity than the others concentration of *Bacillus* sp. liquid added tray. Within the experiment, the added *Bacillus* sp. pots showed better length and weight of crop growth compared to other pots. Therefore, adding *Bacillus* sp. to crop residue compost is recommended. Plus, adding *Bacillus* sp. has positive influence to crop growth.

This experiment was carried out during summer season in Tokyo (Japan). Temperature has a significant impact with crop residue composting. Therefore, location and temperature are two important factors to be taken into consideration in this study.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the support made by members of Lab. of Land and Water Use Engineering, Tokyo University of Agriculture, Japan.

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