Simulation experiment of organic farming system: changes of soil organic carbon and microbial communities by organic fertilization

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Key words: organic farming system, organic fertilization, soil microbial community

Abstract

Soil beneficial microbe products were used in organic farming system as soil amendment. Effects of different organic fertilization on soil organic carbon (SOC) and microbes were analyzed in this study in order to improve fertilization technology. Culture experiment in the lab was designed to simulate organic farming system and exclude uncertain factors of environment and human operations. Results showed that beneficial microbe with organic fertilizer applied in soil accelerated decomposition of SOC significantly compared to single organic fertilizer treatment. Photosynthetic Bacterium (PSB) liquid applied in soil increased soil bacterial colonies and declined soil fungal colonies significantly compared to other treatments on the 40th day. Bio-fertilizer treatment increased soil fungal colonies, but this effect was not significant.

Introduction

Organic farming aims to develop fertile soil with sufficient organic matter and microbes. Soil microbe, which controls the key process of soil ecosystem, is the most active ingredient in soil. Bacteria, fungi and actinomycetes are three main categories of microbes influence the SOC cycle. Studies showed that organic fertilizer application in soil with beneficial bacterial, e.g. PSB, improved organic nutrient cycle in soil and increased chlorophyll content and yield of the crop (Zhang et al., 2008). In view of the irreplaceable effects of soil microbes on soil fertility, microbial products and their extracts are allowed to use in the organic farming system. In this study, we intend to improve fertilization technology by simulating organic farming system and analyzing changes of SOC and soil microbial communities in the culture experiment.

Material and methods

The soil of this study belonged to the *Fimic Anthrosol* developed from the *Haplic Luvisol* and was collected from Nanjing Planck Organic Farm in China. The farm has been treated by organic management since 2002. Soil physicochemical and microbial properties at the beginning of this study were shown in Table 1. The organic fertilizer of this study was commonly used in the organic farm (organic matter 190 g Kg^{-1}, total nitrogen 13.8 g Kg^{-1} and available nitrogen 612.5 mg Kg^{-1}). The bio-fertilizer was consisted by decomposed organic matter and beneficial microbes screened directionally from healthy soil (viable count ≥ 0.5×10^{8} CFU g^{-1}, organic matter 150 g Kg^{-1}, total nitrogen 5.8 g Kg^{-1} and available nitrogen 296.5 mg Kg^{-1}). PSB strain of study was *Rhodopseudomonas sphaeroids x3* (viable count ≥ 1.2×10^{9} CFU mL^{-1}).

Four treatments of different fertilization were designed and replicated 3 times: treatment OF (organic fertilizer 2.25g), OPF (organic fertilizer 2.25g + PSB liquid 3mL), OWF (organic fertilizer 2.25g + aseptic water 3mL, as the contrast of OPF), OBF (organic fertilizer 2.25g + Bio-fertilizer 0.12g). 400g sieved fresh soil sample was mixed well with different fertilizer into a tall glass beaker (500mL) for every treatment. Parafilm (breathable, waterproof and antipollution) was covered on top of the beaker. Above operation was completed as soon as possible to keep soil moisture after the soil was collected from the organic farm. Whole culture time was set for 60 days and all culture devices were kept in 25 ℃. Periodically destructive sampling was set for once every 20 days. Dosage of different fertilizer was designed based on soil bulk density and farming conditions of the organic Farm. Colonies of soil bacteria, fungi and actinomycetes were calculated by dilution plate counting method (Lin, 2010). Soil properties were analyzed according to the standard methods. Data was expressed as mean ± S.E. Significant differences were calculated at $P<0.05$ and $P<0.01$ by ANOVA.

Results

As was shown in Fig.1A, no difference of SOC was analyzed among different treatment on the 20th and 40th days. SOC was significantly higher ($P<0.01$) in OF and OWF compared to OPF and OBF in the end. Soil microbial biomass carbon (MBC) was distinctly higher ($P<0.05$) in OPF and OBF compared to OF and OWF

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on the 20th and 40th days (Fig.1B). Soil mineralized carbon was significantly higher ($P<0.01$) in OPF compared to other groups in the end (Fig.1C). It was significantly higher in OWF compared to OF after 20 days. Soil microbial colonies of four groups were declined gradually during whole culture time (Fig.1D to Fig.1F). Soil bacterial colonies of OPF were more than that of OF and OWF, which was remarkable on the 40th day (Fig.1D). No statistic difference of soil fungal colonies were found between OF and OBF (Fig.1E). It was less in OPF compared to other groups on the 40th day, with significant difference ($P<0.05$). As was shown in Fig.1F, soil actinomycetes colonies of OPF was more than other treatments on the 60th day, with significant difference ($P<0.01$).

Table 1: Soil physicochemical properties and microbial properties at the beginning of this study

Soil physicochemical properties		Soil microbial properties	
Soil organic carbon (g Kg^{-1})	19.82±0.30	Microbial biomass carbon (mg Kg^{-1})	344.55±29.08
pH	6.41±0.08	Microbial biomass nitrogen (mg Kg^{-1})	62.70±2.40
Total nitrogen (g kg^{-1})	1.81±0.05	Bacterial colonies (×10^6 CFU g^{-1})	9.32±0.56
Available phosphorus (mg kg^{-1})	43.86±2.54	Fungal colonies (×10^4 CFU g^{-1})	7.24±0.97
Available potassium (mg kg^{-1})	216.31±20.13	Actinomycetes colonies (×10^5 CFU g^{-1})	14.06±0.37
Mineralized carbon (mg kg^{-1})	356.27±35.72		

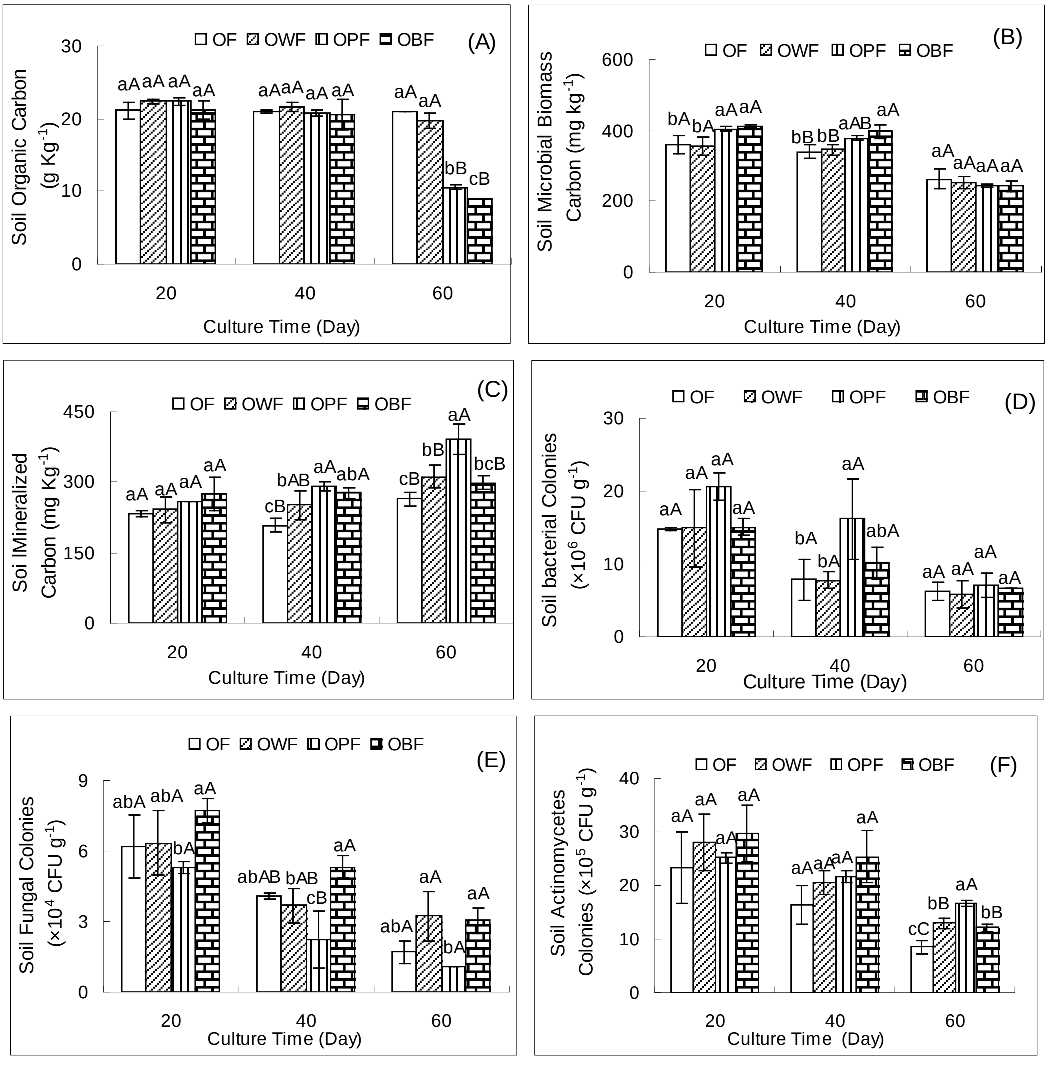

Fig. 1 Changes of soil organic carbon (A), soil microbial biomass carbon (B), soil mineralized carbon (C), soil bacterial colonies (D), soil fungal colonies (E) and soil actinomycetes colonies (F) by different fertilizatiton treatment

Different capital and small letters show significant differences at the levels of 0.01 and 0.05 under different management.

Discussion

Beneficial microbes with organic fertilizer applied in soil increased MBC and transformed soil microbial community structure. Soil mineralized carbon, which is CO_2 contents released by decomposition of SOC, can be interpreted as bio-degradable carbon in soil. As culture time went by, mineralization process continued and SOC contents declined gradually. It was noteworthy that beneficial microbe applied in soil accelerated decomposition and mineralization of SOC. No difference of soil MBC was found among different treatment in the end indicated that survival competition among microbes intensified and consumption of labile SOC increased. When microbial products were applied in soil with organic fertilizer, additional organic fertilizer should be supplemented into soil at the end of the cultivation.

References

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