CONTROL OF BANANA FUSARIUM WILT DISEASE BY BIOLOGICAL SOIL DISINFESTATION

Xinqi Huang*, Teng Wen, Jinbo Zhang, Zucong Cai

Abstract: Banana Fusarium wilt caused by *Fusarium oxysporum* f. sp. *cubense* (FOC) is a worldwide soil-borne disease that causes serious economic losses every year. Traditionally, farmers use chemical pesticides and disease-resistance cultivars as relatively dependable methods of protecting banana from FOC. However, increased use of chemical pesticides have several negative effects on the environment and human health and restrictions have increased on use of a variety of chemical pesticides. The disease-resistance cultivar usually leads to an increase in fertilizer input and a reduction in banana quality. Therefore, there is an urgent need for effective ways to eliminate FOC from soil and then control banana Fusarium wilt diseases. Recently, biological soil disinfestation (BSD) increasingly used in USA, Netherlands and Japan is considered as an effective and environmentally friendly way to suppress soil-borne pathogens. In this study, BSD with incorporation of various organic matters under flooding conditions combined with plastic mulching were applied to suppress FOC and prevent banana Fusarium wilt disease. The biological properties of the soil during the BSD process were investigated using quantitative real-time PCR and denaturing gradient gel electrophoresis. Besides, high performance liquid chromatography was used for investigating the role of organic acids in the mechanisms of BSD. The results showed that the values of soil redox potential significantly decreased by >800 mV in the BSD treatments incorporated with rice straw and bagasse under flooding conditions compared with untreated soil. The lowest soil pH (5.36) and a significant decline in the *F. oxysporum* population to 2.79% of untreated soil were obtained in flooded soil with the highest amount (1.2%, w/w) of rice straw (C/N, 46.0). Incorporation of bagasse (C/N, 129.6), pig manure (C/N, 12.8), and lime also significantly decreased the populations of *F. oxysporum*, but were less effective than rice straw. Application of rice straw under flooding conditions significantly decreased fungal diversity and increased soil bacterial diversity, and the increased bacteria, such as *Clostridium* spp. regarded as organic acids producers, were considered to have an antagonistic effect on *F. oxysporum*. In a field experiment, a wilt disease control efficiency of 82.3% was obtained in flooded soil incorporated with 0.5% (w/w) rice straw compared with untreated soil. Besides, four kinds of toxic organic acids to *F. oxysporum* were detected in soil solutions of BSD treatments. Acetic acid and butyric acid were the primary organic acids, followed by small amounts of isovaleric acid and

propionic acid. Furthermore, there was a significant negative correlation between the population of *F. oxysporum* and the total amount of toxic organic acids in BSD. These results indicated that BSD could reduce FOC populations in soil, ameliorate soil microbial communities, and prevent the occurrence of banana Fusarium wilt disease. Organic acids produced in BSD process contributed to the disinfestation effect of BSD. Although BSD is an effective method of preventing banana Fusarium wilt disease, in practice, how to hold the soil water in BSD process and recover the soil permeability after planting bananas is still a problem.

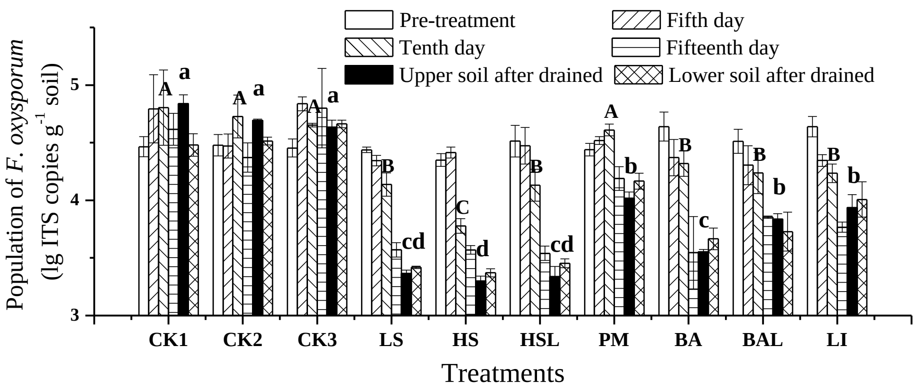

Fig. 1 Real-time PCR quantification of *F. oxysporum* internal transcribed spacer (ITS) copies in different treatments during the flooding process and after the soils were drained. Note: CK1, untreated soil; CK2, disturbed soil without flooding; CK3, disturbed soil with flooding; LS, flooded soil incorporated with 0.6% (w/w) rice straw; HS, flooded soil incorporated with 1.2% (w/w) rice straw; HSL, HS plus 0.3% (w/w) lime; PM, flooded soil incorporated with 1.6% (w/w) pig manure; BA, flooded soil with 1.2% (w/w) bagasse; BAL, BA plus 0.3% (w/w) lime; and LI, flooded soil with 0.3% (w/w) lime. Bars with the same letters are not statistically different between the different treatments following Student-Newman-Keuls tests ($P < 0.05$). Error

bars indicate standard errors

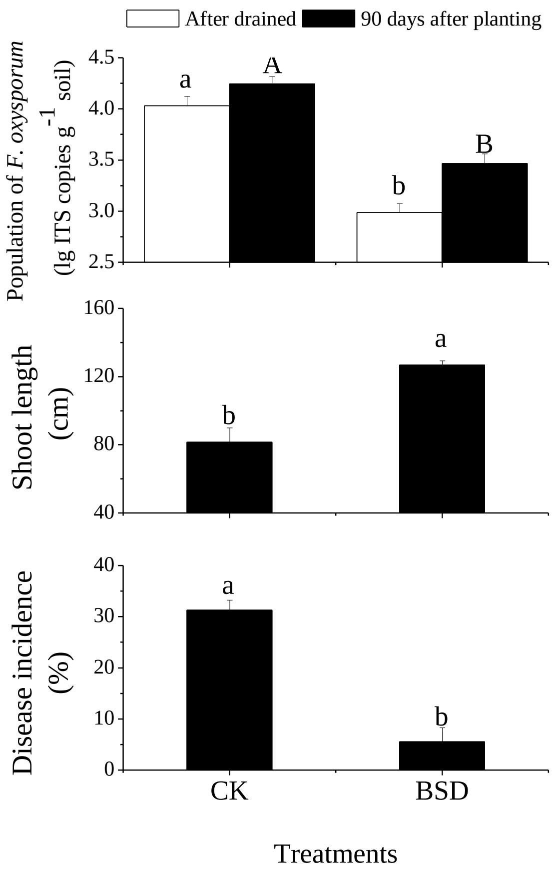

Fig. 2 The number of *F. oxysporum*, the disease incidence, and shoot lengths of bananas in the field experiment. Note: bars with the different letters are statistically different following Student-Newman-Keuls tests ($P < 0.05$). Error bars indicate standard errors

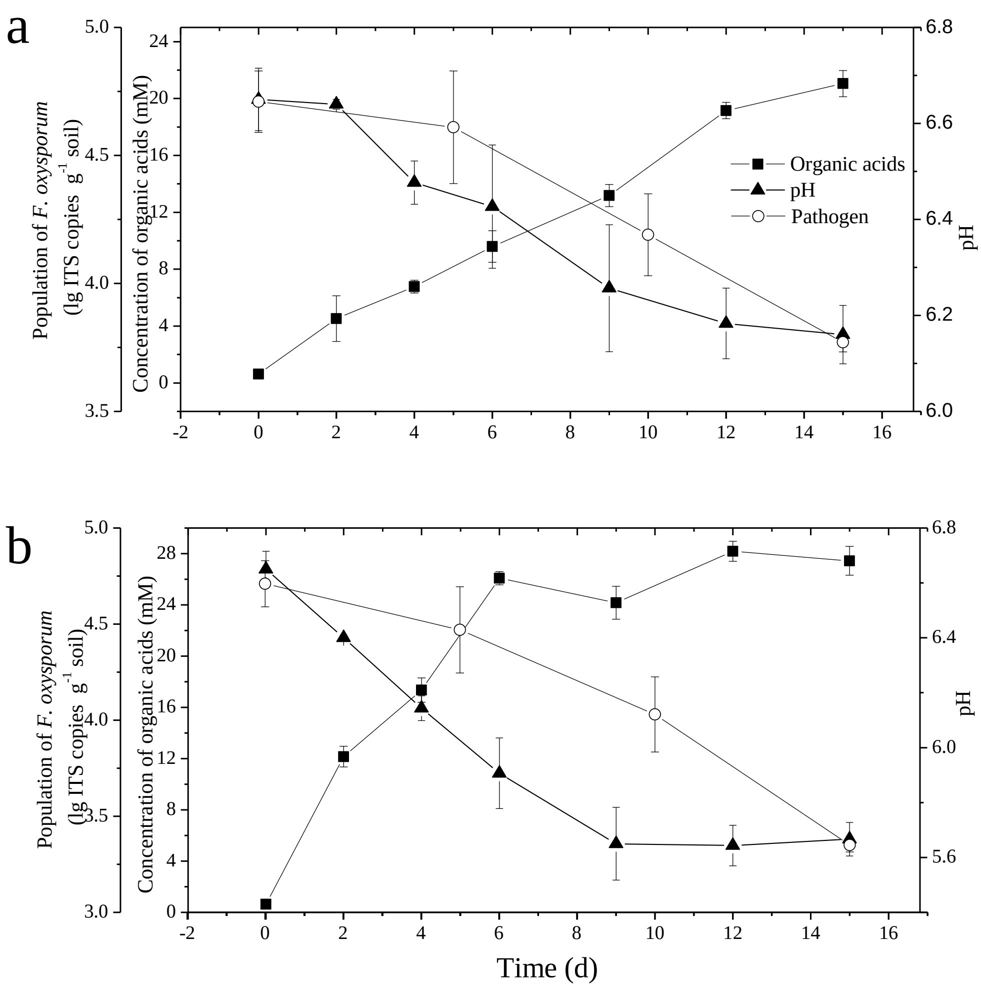

Fig. 3 The variations of soil pH, organic acids and the pathogen from 0-15 days after flooding in 1% maize straw amended (a) and 2% maize straw amended (b) BSD treatments. The concentrations of organic acids were the sum of acetic, propionic, butyric and isovaleric acids. Error bars indicate standard deviations