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Topic 2 - Product and process quality in Organic Agriculture: methods and challenges

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BIOPESTICIDE COMPOST FROM FOOD WASTE AND CHINESE MEDICINAL HERBAL RESIDUES

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Abstract: Pest issue remains as one of the major factors reducing crop yields of local organic farmers in Hong Kong, especially due to increase in soil temperature caused by climate change in recent years. An innovative composting approach has been proposed by co-composting food waste (FW) with Chinese medicinal herbal residues (CMHR) to produce low cost compost with bio-pesticide properties derived from CMHR. Their antipathogenic effect against the pure culture of two phytopathogens, *Alternaria solani* and *Fusarium oxysporum* were ~54% and ~38% higher than that of food waste compost, respectively. Mature compost at 0, 2.5, 5 and 10% was respectively applied to soil inoculated with either *A. solani* or *F. oxysporum*. The results showed that 5% (dry weight basis, w/w) FW-CMHR compost was the optimum application rate, and was about 1.2 times and 2 times that of the yield of Chinese cabbage and cherry tomator growing in control soil without inoculum.

Introduction: Soil-borne pathogens are the main threat to organic farmers due to the limited effective biopesticide available in the market. In Hong Kong the rise in temperature due to climate change has increased the pest diseases making it more difficult for organic farm operators. Fusarium wilt caused by *Fusarium oxysporum* in tomato plants and early blight affected by *Alternaria solani* in cabbage crops are the most serious ones causing crops, respectively (Koné et al., 2010). Recently, the use of Chinese medicine herbal residues (CMHRs) as a co-composting substrate to compost with food waste was reported with a view to achieve the disposal of both types of wastes and in the same time to produce compost with high anti-pathogenic properties (Zhou et al., 2014). The mature compost is rich in fungal biological control agents which inhibits a wide range of plant pathogens (Verma et al., 2007) and there is a lack of knowledge of about the antipathogenic effect of FW-CMHRs compost and its effectiveness following land application. Hence, the aim of this study was to evaluate the effectiveness of the antipathogenic property of the FW-CMHRs compost in soil inoculated with two plant pathogens, *A. solani* and *F. oxysporum*.

Material and methods: 2.1. Soil and mature compost samples

The soil was collected from top 15 cm layer from a non-cultivated area of a local vegetable field (Produce Green Foundation) in Hong Kong. Two different types of compost were prepared after composting of food waste (FW) and saw dust (SD) in 1:1 ratio (termed as FW compost), and FW:SD:CMHR in 1:1:1 ratio (termed as CMHR compost) (Zhou et al., 2014).

2.2. Antipathogenic effects

To study the antipathogenic effects, the acetone extracts of pure CMHRs and matured composts were obtained using solid: liquid ratio of 1:10 (w/v, dry weight basis). The phytopathogens, *A. solani* (CBS 110.41) and *F. oxysporum* (CBS 186.53), were purchased from the Central bureau voor Schimmelcultures, Netherland. *A. solani* and *F. oxysporum* cakes (diameter of 1 cm) were inoculated in the middle of the plates and reverse cultivated for 9 days at 28^{o}C along with distilled water for blank test. The diameters of pathogenic colony sizes were measured by using straight cross method daily and the inhibition rate was calculated using formula as shown below.

$$\text{Inhibition rate (\%)} = \frac{\text{Colony dia. of control} - \text{Colony dia. of treatment}}{\text{Colony dia. of control}} \times 100$$

2.3. Greenhouse plant growth experiment

Cherry tomato (*Lycopersicon esculentum*) and Chinese cabbage (*Brassica chinensis*) were selected for this experiment due to their adaptability to tropical, warm and wet conditions of Hong Kong. Two types of phytopathogenic fungi namely, *Alternaria solani* (on tomato plants) and *Fusarium oxysporum* (on cabbage plants) were chosen as sources of infection tomato and Chinese cabbage respectively after their growth on PDA plates for 9 days.

All soils were inoculated with plant pathogens by mixing the spore suspensions with 1/4 of the top soil/compost mixtures with either *F. oxysporum* at a density of 10^6 spores/g or *A. solani* at a density of 10^5 spores/g before mixing with 0, 2, 5 and 10% (dry weight basis, w/w) of FW-CMHR compost. As a control, inoculated soil was amended with 5% food waste compost as a control against 5% FW-CMHR compost. Two treatments with soil receiving no inoculum were prepared with or without chemical fertilizer application. Cherry tomato and Chinese cabbage were planted for 7 and 9 weeks respectively before harvesting. The dry biomass was measured after oven-dried the harvested plants at 55^{o}C until constant weight.

Results: 3.1. Properties of soil and mature compost

The properties of soil and mature composts are listed in Table 1. The collected soil was acidic in nature (pH=4.33) with lower EC (0.24 dS/cm), whereas FW compost and FW-CMHR compost had pH of ~8 and EC of ~5 dS/cm. The total nitrogen in soil was 852 mg/kg whereas the compost samples were richer in nitrogen content (13560-17400 mg/kg). The phosphorous concentration in compost samples were approximately 10 times higher than in soil. The potassium concentration in soil was 700 mg/kg whereas the FW compost and FW-CMHR compost samples had 14.6 mg/kg and 18.3 mg/kg, respectively.

Table 1. Physicochemical properties of soil, FW compost and CMHRs compost

Parameters	Soil	FW compost	FW-CMHRs compost
pH	4.33 (0.08)	8.08 (0.40)	7.95 (0.47)
EC (dS/cm)	0.24 (3.54)	5.45 (0.43)	5.34 (0.21)
TOC (%)	0.92 (0.29)	37.79 (4.19)	38.98 (6.12)
TKN (mg/kg)	852 (100)	13560 (855)	17400 (2032)

TP (mg/kg)	702 (200)	7198 (668)	8796 (671)
TK (mg/kg)	9.54 (0.30)	14.6 (0.45)	18.3 (0.16)

Values in parentheses are standard deviation (n=3)

3.2. Anti-pathogenic effects of CMHR and compost extracts

In-vitro experiments were conducted to evaluate the anti-pathogenic characteristics of acetone extracts from pure CMHR and two mature composts against *A. solani* and *F. oxysporum*. The acetone extraction of CMHR showed the best performance in suppressing fungal growth, with the inhibition ratio of 75.6% and 54.3% for A. *solani* and F. *oxysporum* respectively (Figure 1). The results found to be similar with that of acetone extracts of FW-CMHR compost (75.8% and 59% for *A. solani* and *F. oxysporum* respectively). The inhibition ratio was ~35% for FW compost samples for both phytopathogens. This indicates that co-composting with CMHR increased the anti-pathogenic property of the final compost as compared to food waste compost alone.

3.3. Plant biomass production

The control soil without inoculation with fertilizer application resulted in the highest dry weight yield for both cherry tomato (2.36 g pot^{-1}) and Chinese cabbage (0.47 g pot^{-1}) (Figure 2). This confirms the crop damage by phytopathogens by inhibiting the nutrient absorption from environment by plant roots. However, for *B. chinensis*, the growth in the control soil was even better than the one with 5% FW compost, indicating the short growth period and the pathogenic effect were higher than the nutrient effect. For *L. esculentum*, the long growing period did counteract against the negative effect of pathogens on plant growth as evidenced by the high yield with 5% FW compost amended soil as compared to the control soil without fertilizer amendment.

In contrast, with the inoculation of plant pathogens, the biomass of treatments with 5% FW- CMHR compost showed the highest biomass production for both crops (4.8 g pot^{-1} for cherry tomato and 0.59 g pot^{-1} for Chinese cabbage) indicating this was the optimum application rate. With an increase in compost application to 10%, the biomass production was inhibited slightly (4.1 g pot^{-1} for cherry tomato and 0.57 g pot^{-1} for Chinese cabbage) due to the higher salt contents and the phytotoxicity of bioactive compounds in the CMHR. The biomass production of cherry tomato and Chinese cabbage was 100% and 20% higher than their counter parts in soil without inoculum indicating the effectiveness of FW- CMHR on suppressing the soil pathogens and the provision of nutrients for plant growth.

Discussion: Addition of compost and FW-CHMR compost demonstrated a positive pH buffering effect on the acidic soil and the pH increased from ~4 to ~7 which is an essential factor of devitalizing phytopathogens as well as optimum for nitrifying bacteria and nitrogen-fixing bacteria (Rifat et al., 2010). Both FW and FW-CHMR composts had higher EC due to large quantities of soluble salts in FW, and their application significantly increased the soil EC. However, the ECs of all compost application rates were all below the limit of 2 dS/cm for sensitive crops. The soil with mature composts application had higher nutrients than the control soil which are favourable for plant growth. The antipathogenic studies revealed that the FW-CMHR composts can be a potential biological anti-pathogenic agents against the two phytopathogens *Alternaria solani* and *Fusarium oxysporum*. The greenhouse experiment indicated that 5% FW-CMHR compost was the optimum application rate which could effectively suppress the soil pathogen and provide sufficient nutrients for crop growth. This provides a low cost effective biopesticides compost for organic farmers.

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Image:

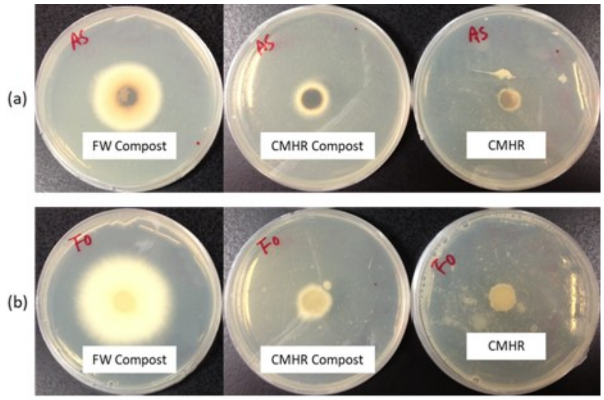

Figure 1. Antipathogenic effects of mature composts and pure CMHR on (a) *A. solani* and (b) *F. oxysporum*

Image 2:

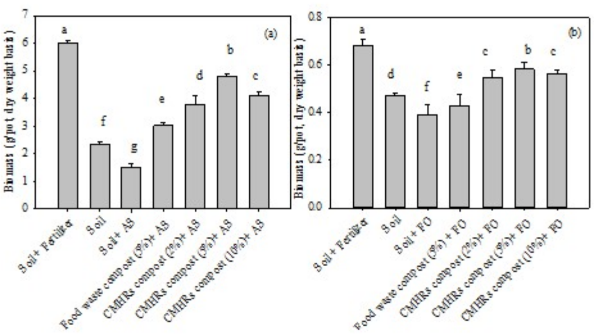

Figure 2. The dry weight yields of (a) *Lycopersicon esculentum* and (b) *Brassica chinensis* in soil with various application rates of mature compost (AS: *Alternaria solani*; FO: *Fusarium oxysporum*

Disclosure of Interest: None Declared

Keywords: food waste, biopesticide, Chinese medicinal herbalresidues, composting, crop growth