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Bio-efficiency of compost extracts on the wet rot incidence, morphological and physiological growth of okra (*Abelmoschus esculentus* [(L.) Moench])

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ABSTRACT

An experiment was carried out to investigate the efficacy of rice straw and empty fruit bunch (EFB) of oil palm compost extracts either fortified or unfortified with *Trichoderma harzianum* on morpho-physiological growth and occurrence of Choanephora wet rot of okra. Treatments tested were water (control) (T1), rice straw (RST) compost extract (T2), *Trichoderma*-enriched RST compost extract (T3), empty fruit bunch of oil palm compost extract (T4), *Trichoderma*-enriched EFB compost extract (T5), aqueous suspension of *Trichoderma* (T6), and a fungicide Dithane M-45® ($2\ g\ l^{-1}$ of water) (T7). The experimental results revealed significant variations amongst the treatments in respect of morphological characters, e.g. shoot length, tap root length, number of leaves per plant, and leaf area. The shoot and tap root length, number of leaves per plant, leaf area were significantly ($P \leq 0.05$) higher in *Trichoderma*-enriched RST compost extracts (T3) followed by Dithane M-45® (T7), *Trichoderma*-enriched EFB extracts (T5), RST (T2), EFB (T4) and aqueous suspension of *T. harzianum* (T6) in both *Choanephora* inoculated and uninoculated (control) plots. Similarly, net photosynthetic rate and chlorophyll content were higher in plants receiving *Trichoderma*-enriched RST compost extracts (T3) with 76.2% reduction in Choanephora wet rot incidence when compared with rest of the treatments. These experimental results revealed that morpho-physiological characters of okra could be modified by the application of *Trichoderma*-enriched compost extracts. This suggests that use of *Trichoderma*-enriched compost extracts would be more beneficial in environmentally friendly okra cultivation and may be used as an alternative to inorganic fertilizers/fungicides to enhance plant growth and reduce disease incidence subsequently, resulting in higher yield.

1. Introduction

Vegetable crops are grown and consumed worldwide as a source of nutrients and fiber in the human diet. Malaysia produces vegetables of about 250,000 Mt/year (FAO, 2001). In Malaysia, commercial production of vegetables is increasing as a result of the growing demand from towns, cities and rural areas. More than 50 kinds of vegetables are planted in Malaysia importantly okra, chilli, cabbage, tomato, members of cucurbits, and others. Due to high humidity and temperature these vegetables are prone to many fungal diseases causing severe losses. Amongst them shoot and flower blight or Choanephora wet rot has been documented as one of the most commonly observed disease infecting okra and other vegetables ultimately reducing the yield. This disease has been reported from countries of subtropical climate such as North America, Egypt and India with the losses in the magnitude of 5–50% (Sherf and Mac Nab, 1986).

The use of fungicides, namely benomil and mancozeb (Dithane®) is recommended to control the disease. There are few cultural control methods currently available for this problem under the present growing conditions. Application of fungicides contributes to high productivity through increased and stabilized yields and reduction in cost of production. However, their long-term usage can have a negative impact on the environment. The Environmental Protection Agency (EPA) has removed several fungicides from the market because of ground water contamination and harmful effects on wild life and human health (Crnko et al., 1992).

On the other hand, large quantities of agro-waste are generated every year in Malaysia as a result of crop production. Rice, oil palm, rubber, cocoa and vegetable crops are just a few examples of crops that generate considerable amounts of waste. Proper utilization

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and disposal of agro-waste such as rice straw (RST) and empty fruit bunches (EFBs) of oil palm is one of the major problems in Malaysia due to high cost of collection and transportation, pollution emission, loss of nutrients when burned, and as a source of disease inoculum when incorporated into the soil. The disposal was through clean clearing technique, which includes burning and re-burning, is found to pollute the air and is costly. In view of this, the government of Malaysia had imposed a ban on open burning in 2000 under Environmental Quality Act (EQA, 1974). Recently recycling of the waste material was carried out by producing compost and subsequently, compost extracts which can be used as an organic fertilizer and as a soil conditioner on farms. It has been recognized as one of the most cost effective, environmentally sound alternative for organic waste recycling, and is well known for its potential disease suppressive characteristics (William, 2001).

Compost and compost extracts applied to soil improve its quality by altering the chemical and physical properties, increase organic matter content, water holding capacity, overall diversity of microbes, provide macro- and micronutrients essential for plant growth and suppress diseases which indirectly contribute to plant growth enhancement (Weltzien, 1991; Scheuerell and Mahaffe, 2004; Sylvia, 2004; Heather et al., 2006). Certain microorganisms present in the compost and compost extracts such as *Trichoderma*, *Rhizobacteria* and fluorescent *Pseudomonas* are known to stimulate plant growth (Hoflich et al., 1994; Glick, 1995; Sylvia, 2004). These microbes benefit plants through different mechanisms of action, including the production of secondary metabolites such as antibiotics and hormone-like substances, the production of siderophores, antagonistic to soil-borne root pathogens, phosphate solublization and nitrogen fixation (Dubeikovsky et al., 1993). The bio-efficiency of compost extracts, therefore, could also be further enhanced by fortifying it with plant nutrients or biocontrol inoculants such as *Trichoderma* spp. *Trichoderma* spp. alone or in combinations with other beneficial microorganisms has been documented as the most common and effective biocontrol agent for disease control in various host–pathogen system *in vitro* as well as in field trials (Jinantana and Sariah, 1998; Ibrahim, 2005). In view of above this study was therefore carried out to determine the efficiency of *Trichoderma*-enriched rice straw and empty fruit bunch of oil palm compost extracts as an alternative to chemical fungicide (Dithane M45®) on morpho-physiological growth and occurrence of Choanephora wet rot in okra production.

2. Materials and methods

2.1. Plant materials and growing medium

The experiment was conducted at the farm located in Vegetable Research Area, Universiti Putra Malaysia, Malaysia. Seedlings of local okra *var. five anchor* were grown in free draining polyethylene bags 18 cm × 20 cm (height × width) containing a mixture of topsoil, peat (Kosas-Peat, Kosas PROFIL sdn. bhd.), and sand in the ratio of 3:2:1 (v/v). Processed chicken manure in pellet form (Avanti Green, from Intarsia Sdn. Bhd.) at the rate of 40 g/kg of soil mix was then added to the soil mixture. Seeds were first sown in germination trays in glass house and 3 days after germination uniform seedlings were transplanted at a rate of five plants per bag. Plants were watered daily until treatments began. The daily temperature ranged from 25 to 34 °C with 85–90% R.H. during the study period.

2.2. Compost extracts and Trichoderma inoculant preparation

Two commonly produced agro-wastes RST and EFB were used as substrates for composting which is cost effective, environmentally sound alternative for organic waste recycling and subsequently to be used in compost extract formulations (Yasmeen, 2006). *Trichoderma* strains isolated from 3-month-old RST and EFB composts were grown and maintained on potato dextrose agar (PDA, Oxoid). Isolates identified as *Trichoderma harzianum* were used to prepare the conidial suspension. The conidial suspension was prepared according to the method described by Sariah (1994). Ten milliliters of sterilized distilled water was added into 5-day-old culture of *Trichoderma* and the surface was scraped lightly with a bent glass rod. The conidial suspension obtained was centrifuged for 5 min at 4000 × g and washed twice with distilled water. The conidial counts were adjusted to approximately 5×10^9 con-conidia ml^{-1} using a hemocytometer.

Table 1
Nutritional and humic acid content of rice straw (RST) and empty fruit bunch of oil palm (EFB) compost extracts after 12 days of extraction

Nutrient content	RST	EFB
Nitrogen (%)	2.38a	1.64b
Phosphorus (%)	2.45a	1.81b
Potassium (%)	1.96a	1.06b
Calcium (%)	4.49b	5.37a
Magnesium (%)	0.93a	0.23a
Humic ACID (mg g^{-1})	5.38a	4.71b
pH	6.33a	6.51a
EC	4.23a	3.42b

Means with the same letters within rows are not significantly different at $P \leq 0.05$ using LSD. Each value represents a mean of three replicates. Source: Yasmeen, 2006.

The compost extracts were prepared from 3-month-old chicken manure treated RST and EFB compost (Yasmeen, 2006) according to the method described by Brinton (1995). Extraction period lasted for 12 days and extracts were supplied with continuous aeration using aquarium pumps. The nutritional composition and humic acid contents of RST and EFB compost extracts are tabulated (Table 1). The extracts produced were then fortified with *Trichoderma* inoculants giving the cfu counts of 3×10^7 ml^{-1} at the time of spraying. Surfactant tween 20 at 10 ml L^{-1} was also added to the extracts prior to application to obtain a better coverage of the foliage during spraying. Two-weeks-old okra plants were sprayed until run-off by using backpack sprayer with the following treatments water (control) (T1), RST compost extract (T2), *Trichoderma*-enriched RST compost extract (T3), EFB compost extract (T4), *Trichoderma*-enriched EFB compost extract (T5), aqueous suspension of *Trichoderma* (T6), and a fungicide Dithane M-45® at the rate of 2 g l^{-1} of water (T7). All the treatments were tested on morphological and physiological growth of okra and Choanephora wet rot occurrence. The fungicide Dithane M-45® has been included as one of the treatments as it is one of the most commonly used fungicide recommended for the control of Choanephora wet rot disease. Spraying was repeated at 7 days intervals until the end of the experiment. Plants were watered daily in the morning through sprinkler irrigation for 2 weeks, later at 3 days intervals to ensure adequate moisture in the soil.

The split plot experiment was conducted with planting bags arranged in completely randomize design (CRD) with three replicates; each replicate consisted of 20 plants. Inoculation was carried out by placing naturally *Choanephora*-infected okra plants at random within the plot. The uninoculated plot served as control. The plants were destructively sampled at weekly intervals.

2.3. Plant morphological and physiological growth

The morphological and physiological growth performance of okra plants was assessed at weekly intervals for 5 weeks, based on plant height, number of leaves per plant, tap root length, leaf area and physiological characters like net photosynthesis and