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Effect of EM Burger Dirt on the Enzymatic Activities of the Soil Planted with Bok Choy (*Brassica ruba* subsp. *Chinensis*) †

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Abstract: Soil enzymes secure our food security; however, they are sensitive to abiotic stresses. Solving the global issues of food waste by implementing Burger dirt can be a great solution to secure food security. Food waste Burger dirt substrate (as soil treatment) and leachate (as seed priming agent and liquid fertilizer) were used to grow Bok choy for 4 cycles, where soil pH, cation exchangeable capacity, moisture content, aggregate stability and enzyme activity were determined. All variables were positively corelated except catalase activity. Burger dirt treatment significantly increased soil pH closed to neutral and CEC. Anaerobic Burger dirt-treated soil significantly reduced soil catalase activity. However, it gradually increased throughout the growing cycle. Burger dirt treatment significantly maintained the aggregate stability along growing cycles. Hence, Burger dirt substrate is recommended to improve soil quality in the aspect of pH, CEC and urease activity.

Keywords: plant and animal-based food waste; cook and raw food waste; soil amendment; bokashi; urease activity; catalase activity

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1. Introduction

Soil enzyme is the key driver for our food security. Without soil enzyme, the nutrient cycle will be disrupted due to the inability of plant to uptake certain nutrients. Soil enzyme activity is sensitive to condition in which they work, including pollution and aeration. It is closely related to the amount of soil organic matter, plant, soil, root, and microbial biomass [1]. Not only that, soil enzyme activity is also affected by abiotic factor including pH, moisture content and soil management, mainly affected by artificial pollutant and commercial fertilizer [2]. Burger dirt had significantly improved soil enzyme activity such as acid and alkaline phosphatase and urease activity in corn and coffee production [3]. In addition to that, organic matter like Burger dirt significantly improved soil aggregate stability and brought to enhancement of microbial agent [4,5]. Soil aggregate stability can be affected by soil moisture content, especially in the low moisture content area [6]. Thus, the objectives of this study are to determine the effect and relationship between soil enzyme activity, pH, cation exchangeable capacity, moisture content and aggregate stability through Burger dirt treatment on bok choy.

2. Materials and Methods

2.1. Study Site

The experiment was carried out in a greenhouse, Field 10, Universiti Putra Malaysia. The clay soil was collected from the study site. Bok choy was treated with Burger dirt

(Table 1), with these treatments a combination of Burger dirt substrate and leachate. Burger dirt substrate was applied only once through soil incorporation at the beginning of the experiment. As for the seed, it was treated with Burger dirt leachate for each growing cycle.

Table 1. Burger dirt substrate and leachate treatments.

Treatment	[1] Burger Dirt Substrate	[2] Burger Dirt Leachate	[3] Burger Dirt Leachate
T000	0	0	0
T001	0	0	1
T009 [4]	0	0	9
T010	0	1	0
T011	0	1	1
T100	1	0	0
T101	1	0	1
T110	1	1	0
T111	1	1	1

[1] soil incorporation. [2] seed priming agent. [3] liquid fertilizer. [4] commercial fertilization [7].

2.2. Treatments

There were nine treatments with 3 replications each carried out for 4 growing cycles. The experiment was conducted as destructive sampling. Burger dirt was prepared according to method by [8]. One g of seed was soaked in 500 mL of tap water, overnight with addition of 1 mL Burger dirt leachate (0.2%) for 3 h [9,10] before being sown in peat moss. Burger dirt treated soil was incubated for 45 days. The seedlings were transplanted to the soil after 7 days of germination. A 0.2% of Burger dirt leachate [11] was applied every five-day interval beginning from 8 days after transplanting.

2.3. Soil Analysis

Soil pH was determined using a 1:2.5 (*w*/*v*) soil-water extract [12]. Soil moisture content was measured gravimetrically for 20 g of fresh soil that had been oven-dried at 105 °C until it achieved constant weight [12]. Soil texture and aggregate stability (%) was analysed [13]. Cation exchange capacity was determined by leaching method. Catalase activity was measured by back-titrating residual H_2O_2 with $KMnO_4$ [2,14,15]. Urease activity was determined by using urea as the substrate [2].

2.4. Statistical Analysis

The collected data was subjected to statistical analyses with two-way Analysis of Variance (ANOVA) using R-program statistic software. When F was significant at the $p < 0.05$ level, treatment means were compared and separated using the Duncan Mean Range Test (DMRT). Pearson's correlation was analysed by package "corrplot" [16].

3. Results and Discussions

All variables were positively corelated to one another except for catalase activity. Catalase activity was significantly negative corelated to pH [17]. However, catalase activity was significantly negative corelated to CEC which contrasts to the previous findings [17]. This may be due to the fact that catalase mainly presents in aerobic organisms [18]. Soil aggregate stability was positively corelated to soil enzyme activity [19].

3.1. Soil Ph

Soil pH had significant interaction between growing cycle and Burger dirt treatment (Figure 1). Soil pH of Burger dirt substrate treated soil significantly increased and maintained along the four cycles of growing. The results were similar to previous studies [20]. Besides, other soil amendments like biochar is also able to stabilize the soil pH under drought conditions [21].

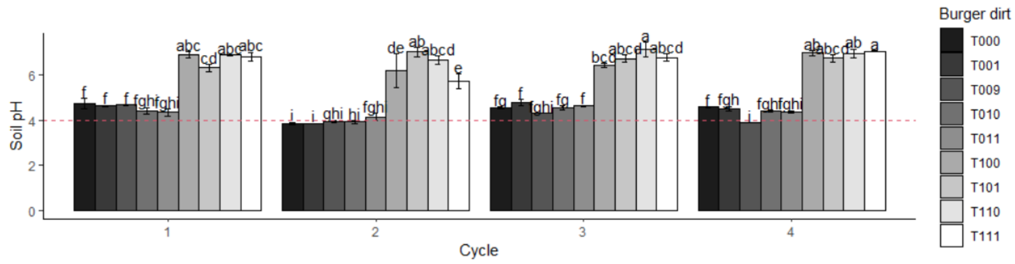

Figure 1. Interaction effect of growing cycle (1, 2, 3 and 4) and Burger dirt treatments on soil pH. Means ± standard error with different letters is significantly different at $p < 0.05$ using DMRT. The dotted line is referred to as original soil pH 4 ± 0.0473.

3.2. Cation Exchange Capacity

There is no significant interaction of cation exchange capacity (CEC) between the growing cycle and Burger dirt treatment (Figure 2). CEC has significantly decreased at fourth growing cycle (Figure 2A). The possible reason is soil organic matter (Burger dirt) has reduced after three growing cycle. This may be due to the Burger dirt being fully degraded by microbes. CEC of Burger dirt treated soil was significantly higher than untreated ones (Figure 2B) [22].

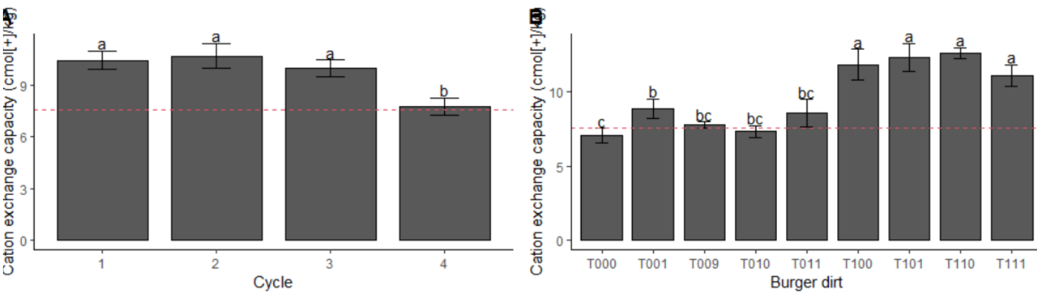

Figure 2. Effect of growing cycle (**A**) and Burger dirt treatments (**B**) on cation exchange capacity ($cmol_+ kg^{-1}$). Means ± standard error with different letters is significantly different at $p < 0.05$ using DMRT. The dotted line is referred to as original cation exchange capacity (7.6 ± 0.216 $cmol_+ kg^{-1}$).

3.3 Soil Moisture Content

There is no significant interaction of moisture content between the growing cycle and Burger dirt treatment. Second and fourth growing cycles showed significantly higher soil moisture content (Figure 3A). Burger dirt treated soil showed significantly higher soil moisture content (Figure 3B) as well. Soil moisture stress significantly declined the plant physiology parameter [23].

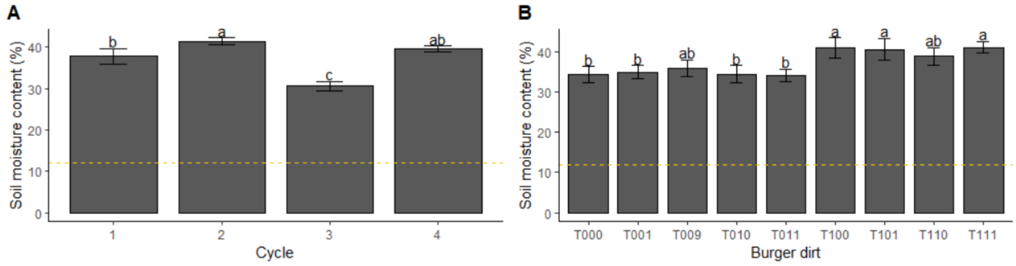

Figure 3. Interaction effect of growing cycle (**A**) and Burger dirt treatments (**B**) on soil moisture content (%). Means ± standard error with different letters is significantly different at $p < 0.05$ using DMRT. The dotted line is referred to original soil moisture content (12 ± 0.286%).

3.4. Soil Aggregate Stability

There is significant interaction in soil aggregate stability between the growing cycle and Burger dirt treatment. Aggregate stability of untreated soil significantly decreased along the growing cycles period (Figure 3). Continuous harvesting may be affecting the soil aggregate. Burger dirt treated soil has significantly stronger aggregate stability along the 4 growing cycles. This is because of the increasing soil organic matter storage by formation of soil aggregate [24].

3.5. Soil Catalase Activity

Catalase was significantly stable in the soil without Burger dirt treatment along the growing cycles (Figure 4). Burger dirt treated soil has significantly lower catalase activity compared to unamended soil along the four growing cycles. This may be due to the production of Burger dirt in the anaerobic condition. Therefore, the anaerobes were predominant in the soil.

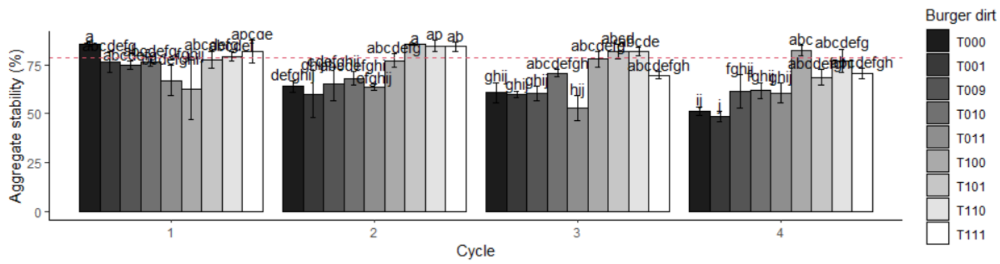

Figure 4. Interaction effect of growing cycle and Burger dirt treatments on soil aggregate stability (%). Means ± standard error with different letters is significantly different at $p < 0.05$ using DMRT. The dotted line is referred to original soil aggregate stability (78.73 ± 0.5679%).

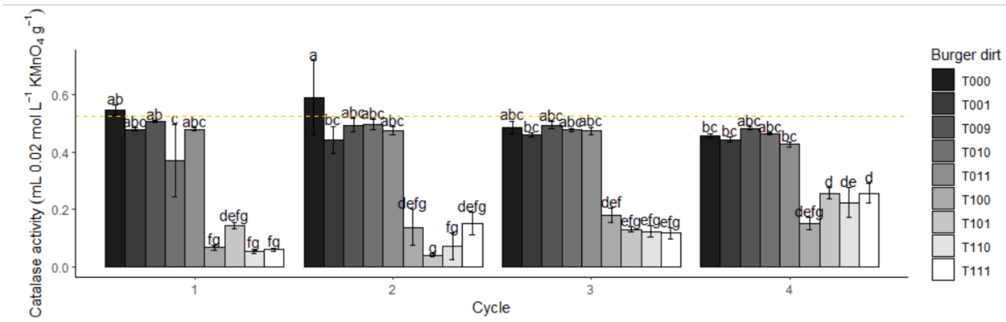

Figure 5. Interaction effect of growing cycle and Burger dirt treatments on catalase activity (mL 0.02 mol L^{-1} $KMnO_4$/g). Means ± standard error with different letters is significantly different at $p < 0.05$ using DMRT. The dotted line is referred to as original soil catalase activity (0.525 ± 0.0104 mL 0.02 mol L^{-1} $KMnO_4$/g).

3.6. Soil Urease Activity

Urease activity has significantly increased with Burger dirt substrate amendment. However, it decreased during the fourth growing cycle (Figure 6). Burger dirt substrate possibly contained high urea in order for urease to work on it. However, the Burger dirt substrate application may be needed to maintain the high urease activity [25].

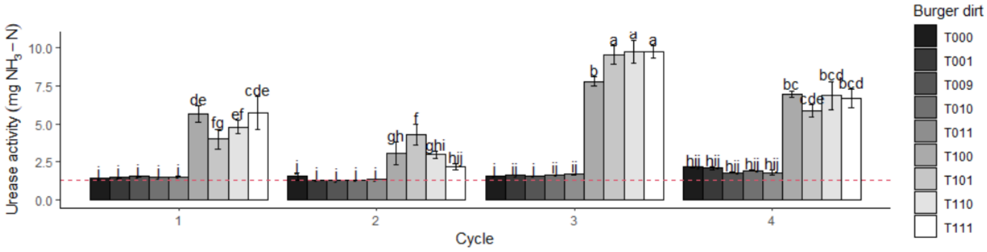

Figure 6. Interaction effect of growing cycle and Burger dirt treatments on urease activity (mg NH_3-N). Means ± standard error with different letters is significantly different at $p < 0.05$ using DMRT. The dotted line is referred to as original soil urease activity (1.33 ± 0.0407 mg NH_3-N).

4. Conclusions

The key player of soil quality was Burger dirt substrate treatment. Soil urease activity, pH and CEC were significantly increased with the treatment of Burger dirt. Therefore, Burger dirt substrate is recommended to improve soil quality.

Supplementary Materials: The following supporting information can be downloaded at: www.mdpi.com/xxx/s1, Figure S1: title; Table S1: title; Video S1: title.

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