Pertanika J. Sci. & Technol. 31 (5): 2303 - 2310 (2023)

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Utilization of Water Hyacinth and Spent Coffee Ground as Raw Materials to Produce Bio-Compost

Thanakorn Saengsanga* and Napat Noinumsai

Environmental Science Program, Faculty of Science and Technology, Nakhon Ratchasima Rajabhat University, Nakhon Ratchasima 30000, Thailand

ABSTRACT

The study aims to utilize water hyacinth and spent coffee grounds (SGC) as raw materials to produce bio-compost and its effects on rice growth. Four different bio-compost formulations were produced. The water hyacinth (6 kg) and dried cow manure (2 kg) were thoroughly mixed and added with SGC+EM (Trial 1), SGC+water (Trial 2), EM (Trial 3), and water (Trial 4). At the end of fermentation, the 3 types of macronutrients (N, P, and K) were determined. Germination percentage and growth in response to this bio-compost were also assessed. The results found that the bio-compost consisted of N, P, and K, ranging from 311–350, 154–197, and 23–25 mg/100 g, respectively. All bio-composts had a favorable effect on the germination percentage, root and shoot lengths, and vigor index of rice seedlings in the seed germination assay. Trial 2 gave the highest root and shoot lengths of 7.32 and 4.35 cm, respectively, and the greatest value of 1051 of the vigor index. At 45 DAS, the results revealed that all trials of bio-compost had a beneficial influence on the development of rice seedlings by increasing root and shoot lengths and fresh and dried weights of rice seedlings, especially Trial 2, which consisted of SGC when compared to the controls. In this phenomenon, the presence of SGC at low concentrations could encourage rice growth.

Keywords: Bio-compost, rice, spent coffee ground (SCG), water hyacinth

ARTICLE INFO

Article history:
Received: 01 July 2022
Accepted: 14 November 2022
Published: 13 July 2023

DOI: https://doi.org/10.47836/pjst.31.5.12

E-mail addresses:
thanakorn.s@nrru.ac.th (Thanakorn Saengsanga)
noinumsai@windowslive.com (Napat Noinumsai)
* Corresponding author

INTRODUCTION

One resource for restoring soil fertility and promoting plant growth is non-traditional organic materials like weeds. Water hyacinth (*Pontederia crassipes*, formerly *Eichhornia crassipes*) is one of the most invasive weed species, causing

ISSN: 0128-7680
e-ISSN: 2231-8526

enormous economic and ecological destruction, especially in tropical and subtropical regions (Jafari, 2010). Water hyacinth can spread rapidly with a daily growth rate of 220 kg/ha and may increase twice after 5–15 days (Islam et al., 2021). Water hyacinth is composed of 74-84 % organic matter, 0.26-0.53% P, 18.5– 27.6% C, 1.18–2.9% N, 2.27–4.53% K, and 15.8–25.1 C/N ratio on a dry matter basis (Su et al., 2018) which a suitable C/N ratio for microorganisms is 15–30 (Haug, 1993). Additionally, the plant has a high concentration of plant hormone, gibberellin, which can boost the growth of plants (Ummah & Rahayu, 2019).

The utilization of water hyacinth as a source of raw materials to produce compost has been studied. As composted material, water hyacinth is increasingly utilized as a source of nutrients (Malik, 2007). Applying bio-compost increases the nutrient storage capacity, water binding capacity, cation exchange capacity, and micro-aggregation in soils. It may reduce the effects of over-fertilization by gradually releasing nutrients (Khan & Sarwar, 2002). Furthermore, manure can improve compost quality, soil fertility, soil productivity, soil organic carbon content, soil microorganisms, soil crumb structure, soil nutrient status, and crop production. Organic manure is particularly economical and effective as a source of nitrogen for long-term crop development (Singh & Kalamdhad, 2015).

Additionally, spent coffee grounds (SCGs) are the residues from the coffee-making process that contain several high-value products. SCGs are generated approximately 6 million tons annually globally (Mussatto, Carneiro, et al., 2011). SCGs mostly consist of polysaccharides, particularly cellulose and hemicellulose, constituting over 50% of the SCG's dry mass. Lignin and protein comprise approximately 20% of the dry mass (Ballesteros et al., 2014) and contain a high value of N, P, and K ranging from 1.2–2.8%, 0.02–0.5%, and 0.35, respectively (Mussatto, Machado, et al., 2011; Cruz et al., 2012). SCGs are used as biomass fuel, organic fertilizer, and soil amendment. Kasongo et al. (2011) reported that the addition of SCGs provides macro-and micronutrients and improves the pH and electrical conductivity of the soil (Cruz et al., 2012) and recommend using it as a soil amendment or fertilizer in agriculture (Cervera-Mata et al., 2018; Gomes et al., 2013). Thai jasmine rice (*Oryza sativa* L. var. KDML105) is among the most popular and economically important cultivars widely produced in northeastern Thailand, where there is soil salinity and low soil fertility. Although applying chemical fertilizers to increase agricultural productivity is a successful strategy, overusing them can harm the environment (Saengsanga, 2018). Consequently, applying organic fertilizers to accelerate soil fertility and increase crop yield is important in sustainable agriculture. Hence, this study aims at assessing the effects of bio-composts produced from water hyacinth and spent ground coffee on the growth of Thai jasmine rice seedlings.

MATERIALS AND METHODS

Harvesting of Water Hyacinth and Collecting of Spent Coffee Grounds

The water hyacinth was collected from the stabilization pond of the Municipal Wastewater Pumping Station (14.9641606N, 102.12496E), Nakhon Ratchasima province. The samples were washed and cut into pieces 3–5 cm long to enlarge the surface area for microbial action. SCG was obtained from a local coffee shop and air-dried to reduce its water content.

Production of Bio-Compost

Four different treatments of bio-compost from water hyacinth and SCG, according to Table 1, all components were mixed and prepared in a plastic bucket of 120 L capacity. Compost was turned out every 14 days, and moisture was maintained at 50–60%. The temperature was taken with a digital thermometer. The color and odor of bio-compost were also observed.

The experiment was performed under natural conditions for 12 weeks until the temperature gradually dropped to ambient air temperatures.

Table 1
Different treatments of bio-compost from water hyacinth

Treatments	Water hyacinth (kg)	Dried cow manure (kg)	SCG (kg)	EM (L)	Water (L)
Trial 1	6	2	0.25	1	0
Trial 2	6	2	0.25	0	1
Trial 3	6	2	0	1	0
Trial 4	6	2	0	0	1

Nutrient Contents

At the end of the composting process, we determined the levels of total N and P according to the method of Bremner et al. (1982) as well as Bray and Kurtz (1945); K was analyzed by atomic absorption spectrophotometer (AAS) (Spectra Ad 55B, Varian).

Determination of the Bio-Compost Maturity by Seed Germination Assay

Phytotoxicity was performed through seed germination assay to assess bio-compost maturity. The plant used in this experiment was jasmine rice *(Oryza sativa* L. var. KDML105). Rice seeds were drenched for 3 min in 90% EtOH and 30 min in 3.5% NaOCl. In the final step, rice seeds were cleaned 3 times with sterile ddH_2O. Each bio-compost sample was diluted with ddH_2O in a concentration of 10% and filtered using filter paper. Sterilized seeds (20/ plate) were germinated in filtrated solution, as mentioned before, in a Petri dish and incubated for 7 days under ambient conditions. Rice plants were irrigated with 3 mL of ddH_2O every 2 days. Germination percentage was observed at 4 days after sowing (DAS). Root and shoot lengths were determined at 7 DAS, and the vigor index of rice seedlings was also calculated according to Equations 1 and 2 (Saengsanga, 2018).

$$\% \text{ Germination} = (\text{Seed germinated} / \text{Total seed}) \times 100 \quad (1)$$

$$\text{Vigor index} = \% \text{ germination x (root length + shoot length)} \quad (2)$$

Effects of Bio-Composts on the Growth of Rice Seedlings

A soil sample was collected from BuaYai District, Nakhon Ratchasima Province, Thailand, to evaluate bio-compost on the growth of rice seedlings by pot experiment. After 7 days of germination, rice was transplanted in a 6-inch pot containing 0.5 kg of soil and fertilized with each bio-compost (50 g/pot). Irrigation was performed, and flooding was 2–5 cm over the soil. At 45 DAS, the growth parameters were collected, including root and shoot lengths and root and shoot dry weight. Vernier calipers determined plant height and weight by analytical balance 4 digits (Denver Instrument, USA) after drying at 70ºC for 2 days.

Statistical Analysis

To determine the significance of the experiments, we presented the results as the mean ± SD of three replicates. Comparison of mean was performed using one-way analysis of variance (ANOVA) with Duncan's multiple range test (DMRT), and $p < 0.05$ was considered to be statistically significant.

RESULTS AND DISCUSSION

Physical and Chemical Properties

Bio-compost samples were gathered after 12 weeks of maturation to examine the main crop nutrients. The compost sample had a range of colors. Trials 1 and 2 were dark brown, while 3 and 4 were light brown (Figure 1).

The bio- compost's N, P, and K contents varied from 311–350, 154–197, and 23–25 mg/100 g, respectively. Furthermore, the pH value of the bio-compost ranged from 8.1–8.4,

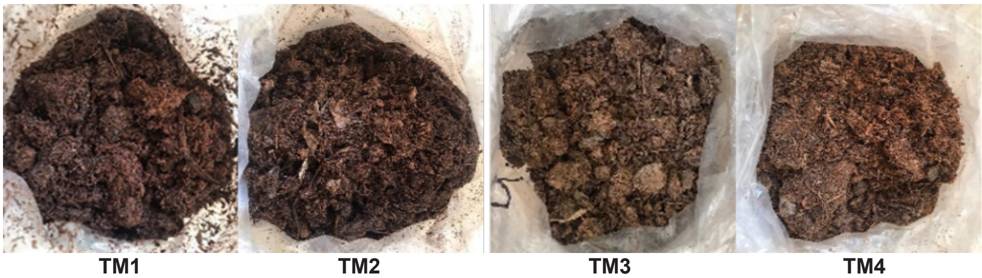


Figure 1. Characteristics of bio-compost

and EC was 4.18–6.29 ds/m (Table 2). Nutrient concentrations often rise due to the net loss of dry mass throughout the composting process (Singh & Kalamdhad, 2015). Besides, the result suggests that adding SCG in an insufficient quantity did not affect the nutritional content of the bio-compost. As a result, adding organic wastes could improve the quality of bio-compost. Islam et al. (2021) claimed that supplementing black liquor and kitchen bio-waste could improve the N, P, and K contents of the water hyacinth bio-compost. A combination of water hyacinth and corncob has various nutrients, including C, N, K, and C/N. At the same time, bio-compost from a combination of water hyacinth and soybean dregs contained more P content (Fitrihidajati et al., 2021).

Table 2
Chemical properties of the bio-compost

Treatments	N (mg/100 g)	P (mg/100 g)	K (mg/100 g)	$EC_{(5:1)}$	$pH_{(2:1)}$
Trial 1	323.42±5.26	179.92±4.84	24.32±0.46	5.78	8.4
Trial 2	311.15±2.98	174.12±4.75	23.32±0.20	6.29	8.7
Trial 3	343.62±4.82	194.97±3.39	25.28±0.03	4.18	8.1
Trial 4	350.67±4.29	197.70±2.36	24.46±0.08	4.68	8.5

Effects of Bio-Compost on Rice Seed Germination

Effects of different bio-composts on germination percentage, plant heights, and vigor index were evaluated, and the result is shown in Table 3. The finding was that all formulations of bio-extract displayed a beneficial effect on germination rate, root and shoot lengths, and vigor index ($p > 0.05$). Trial 2 gave the maximum root and shoot lengths of 7.32 and 4.35 cm, respectively.

Again, Trial 2 was the most efficient stimulator for rice plants, having a maximum vigor index of 1051. The germination assay showed that the bio-compost had no phytotoxicity issues, indicating that these bio-composts produced from water hyacinth and combined with SCG were mature and had no phytotoxicity to inhibit plant growth. It has been documented that SCG at a low concentration (2.5–5%) stimulates plant growth (Gomes et al., 2013).

Table 3
Effects of bio-compost on the germination of KDML 105 rice seeds

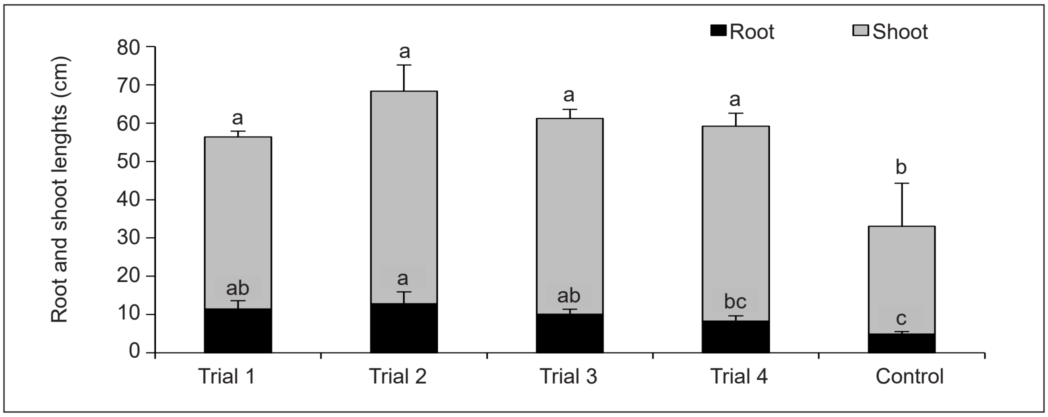
Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Total length (cm)	Vigor index
Control	86.65^{a}	$6.63±0.62^{a}$	$3.71±0.95^{a}$	$9.78±1.21^{a}$	847^{b}
Trial 1	91.65^{bc}	$6.79±0.52^{ab}$	$3.85±0.30^{a}$	$10.64±0.59^{ab}$	975^{ab}
Trial 2	90.00^{ab}	$7.32±0.82^{b}$	$4.35±0.33^{a}$	$11.67±0.70^{b}$	1051^{a}
Trial 3	93.35^{bc}	$6.17±0.80^{ab}$	$4.14±0.28^{a}$	$10.32±1.08^{ab}$	963^{ab}
Trial 4	91.65^{bc}	$7.09±0.17^{ab}$	$4.01±0.11^{a}$	$11.09±0.17^{ab}$	1017^{a}

Note. Values are mean ±SD of 3 replicates with lowercase letters indicating statistically significant differences at $p < 0.05$ (DMRT).

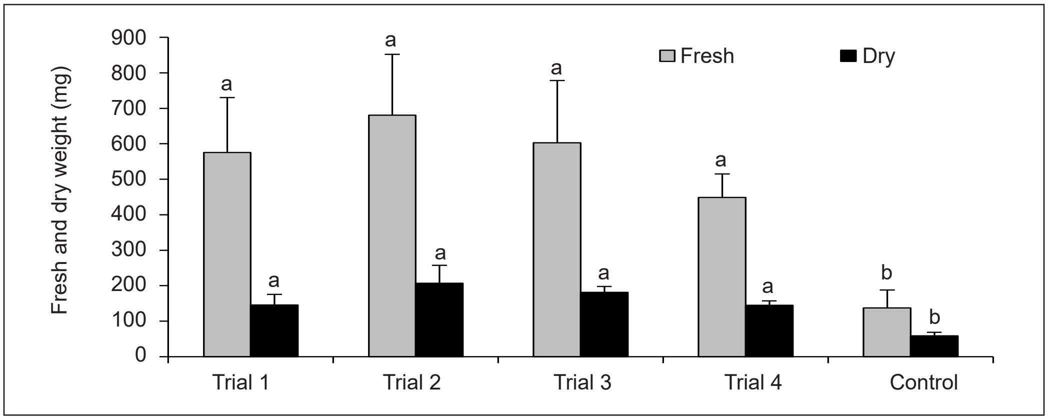
Effects of Bio-Compost on the Growth of Rice Seedlings

We investigated the bio-compost's effects on rice growth under a pot experiment. After 45 DAS, all tested bio-composts boosted the growth of rice seedlings by increasing root and shoot lengths and plant weights ($p < 0.05$) (Figure 2). Rice seedlings fertilized with Trial 2 had the greatest shoot and root lengths and biomass, followed by those with Trial 3.

However, all seedlings' exposure to bio-compost was revealed to be higher than the controls, suggesting bio-compost accelerates the development of the rice seedlings. The utilization of water hyacinth compost can improve the growth and flowering of *Crossandra* and some vegetables compared to untreated plants (Gajalakshmi & Abbasi, 2002). Beesigamukama et al. (2018) reported that water hyacinth bio-compost enhanced maize yield. Hence, water hyacinth-based compost is a good option to improve soil quality and increase plant productivity.



(a)



(b)

Figure 2. Effects of the bio-composts on the growth of rice seedlings at 45 DAS. Root and shoot lengths (a), fresh and dried weights (b). Values are the mean ± SD of tree replicates with the lowercase letters above the bar, indicating statistically significant differences at $p < 0.05$ (DMRT)

CONCLUSION

The outcomes of this investigation have illustrated that the bio-compost derived from water hyacinth and a combination of SCGs is a good soil enrichment to promote jasmine rice plant growth at the seedling stage. Our results revealed that all bio-compost trials had encouraged rice growth, particularly Trial 2 (Water hyacinth: Dried cow manure: SCG: Water = 6: 2: 0.25: 1), having the highest performance. Future investigations should examine the additions of nutrient-rich organic wastes to enhance their qualities.

ACKNOWLEDGEMENTS

The authors acknowledge the support of the Nakhon Ratchasima Rajabhat University, Thailand, for this manuscript completion. The authors would also like to thank Miss Jiratikorn Jinda and Miss Thanpitcha Jantai for their assistance and service.

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