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EFFECTS OF *Gliricidia sepium* RESIDUE VERMICOMPOST ON THE YIELD AND DRY MATTER BIOMASS OF ORGANIC CHOY SUM MUSTARD

INTAN NADHIRAH MASRI[1*], TOSIAH SADI[1], DALJIT SINGH KARAM[2], ARINA SHAIRAH ABDUL SUKOR[2], MOHAMED HAFEIFI BASIR[1], KEEREN SUNDARA RAJOO[3] and ARIFIN ABDU[4]

[1]*Malaysian Agricultural Research and Development Institute (MARDI), 43400 Serdang, Selangor, Malaysia*
[2]*Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*
[3]*Department of Forestry Science, Faculty of Agricultural Science and Forestry, Universiti Putra Malaysia, Nyabau Road, 97008 Bintulu, Sarawak, Malaysia*
[4]*Department of Forestry Science and Biodiversity, Faculty of Forestry, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*
[*]*E-mail: intannadhirah@mardi.gov.my*

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ABSTRACT

As the population grows and resource consumption increases, waste management has become a significant environmental challenge. A more sustainable approach to waste management is essential to maximize the recovery of materials acquired from nature. Vermicomposting is one of the answers to sustainable waste management. A study was conducted to determine the viability of vermicomposting *Gliricidia sepium* leaves and office scrap paper with matured compost as feedstock and to determine the vermicompost characteristics and suitability as potting mixtures for vegetable cultivation. The choy sum mustard was selected as the test crop. The plants were grown in the pots in a netted nursery in Serdang, Selangor. Treatments were mixtures of vermicompost to soil ratio by volume: control (0% no vermicompost), T1 (20% vermicompost), T2 (40% vermicompost), T3 (60% vermicompost), T4 (80% vermicompost) and T5 (100% vermicompost). Physicochemical properties of the potting media mix were determined and compared to an established growth media concentration and other ASEAN standards. Crop growth was evaluated by measuring plant height, the number of petioles, and fresh and dry weights at harvest. A significant improvement in the physicochemical properties of the media was observed, where the optimum ratio of potting media was 60% to 80% (T3 & T4). The number of petioles was 20-46% higher, plants were 39-46% taller, and dry matter accumulation was three-fold higher than controls. Crop yields were 200% higher in media treatments consisting of 60-80% vermicompost. In conclusion, *G. sepium* based vermicompost could be used in media mixtures for potting plants.

Key words: Potting media, soil amendment, vermicast, waste management

INTRODUCTION

Organic wastes are biodegradable materials usually derived from living organisms such as mankind, plants, or animals. Organic waste includes food waste, human waste, paper waste, manure, and agricultural waste. As the population grows, organic agricultural waste indirectly increases due to the extensive farming activities to support the rising food demand. However, increasing agricultural waste has proven to be a challenge to our waste management system. Thus, a more sustainable method to dispose of organic agricultural waste is required. One of the techniques is composting because organic waste can produce usable media to grow crops if composted.

Consequently, vermicomposting has been reported to successfully convert organic agricultural waste into valuable products in recent years. For example, in Malaysia, several studies on vermicomposting using rice husk (Lim *et al*., 2012), urban solid waste (Singh *et al*., 2011), palm oil mill waste (Rupani *et al*., 2013), coconut waste (Tahir & Hamid, 2012), soybean husk (Lim *et al*., 2011), industrial sludge or wastewater (Lee *et al*., 2018), food waste (Othman *et al*., 2012), livestock manure (Azizi *et al*., 2015) and sago pith (Elton *et al*., 2014) had produced significant results. The main reason for such a preference for vermicomposting was the continuous supply of the respective waste materials. However, diverse sources of waste materials lead to different quality and nutrient concentrations in the final compost product (A'ali *et al*., 2017).

* To whom correspondence should be addressed

Apart from the types of raw materials used, the waste quality, the worm species utilized, and the vermicomposting process itself determined the absolute superiority of the vermicompost product (Pattnaik & Reddy, 2010; A'ali *et al*., 2017). According to Ordóñez-Fernández *et al*. (2015), fully decomposed leaves resulted in a higher nutrient release level than fresh leaves. In addition, *Eudrilus eugeniae* worm species were reported to produce more concentrated nutrient content than other worm species (Natarajan & Devi, 2014). Similarly, a closed-liquid-enclosing vermi container is better than an open-liquid drained one because the leachate is confined inside. Hence, the vermicomposting process of using *E. eugeniae* with a semi-decomposed high-quality feedstock may be needed to produce a high-quality vermicompost product.

Gliricidia sepium trees, locally known as bunga jepun or gamal tree, are prominent leguminous trees cultivated in most organic farms and livestock ranches worldwide due to their various functions. This species of the Fabaceae family has been widely introduced across tropical and subtropical regions to be used for fuel wood, animal feed, green manure, shade, poles, living fences, erosion control, soil improver, and as a boundary and support plant (Elevitch & Francis, 2006). In Malaysia, the trimming residue of *G. sepium* has been successfully utilized as green manure or as a raw material used in the thermophilic composting process. Even though vermicomposting was reported to produce a higher nutrient recovery rate than thermophilic composting (Lim *et al*., 2015), to the best of our knowledge, no previous studies have been attempted to investigate the potential of using *G. sepium* pruning waste as feedstock in vermicomposting. Therefore, a study was conducted to determine the viability of vermicomposting *G. sepium* leaves and office scrap paper with matured compost as feedstock and to determine the vermicompost characteristics and suitability as potting mixtures for vegetable cultivation.

MATERIALS AND METHODS

To obtain suitable soil physicochemical properties for growing a full cycle vegetable in the vermicompost: soil (VC:S) mix, these parameters were observed and compared to the suggested values from the literature: nitrate-N, phosphorus, potassium, pH, electrical conductivity (EC), organic matter (OM) content, C/N ratio, bulk density, total porosity, and water holding capacity.

Vermicomposting of waste materials

The vermicomposting materials of the *G. sepium*'s trimmed leaves, office paper waste, and matured yard compost were obtained from the Integrated Organic Farm (IOF) Complex of the Malaysian Agricultural Research and Development Institute (MARDI) Serdang, Selangor. Five kilograms of *G. sepium* leaves, ten kilograms of office scrap paper, and ten kilograms of matured compost were used in the study. *Gliricidia sepium*'s trimmed leaves were pre-composed for five days in a gunny bag under water-saturated conditions. The scrap paper was soaked in chlorine-free water overnight, and excess water was drained off before utilizing it. The vermicomposting process was performed according to the standard methods using one kilogram of African nightcrawler (*Eudrilus eugeniae*) worms in 0.88 m × 2.90 m × 0.30 m concrete vermi pit. These worms were purchased from a worm farm in Alor Gajah, Melaka. The matured yard compost and the office paper waste were laid on the vermi pit floor as bedding materials. The semi-decomposed leaves of *G. sepium* were separated from the stem and spread over the vermi pit materials. Approximately 10 to 16 liters of water were added daily to maintain a 70% moisture level and regulate the pile's temperature. The vermicompost pile was turned over once a week, and the final product was collected after six weeks when all the raw materials were converted into worm casts and compost-like products. The vermicompost was sieved using a 5.00 mm mesh net to obtain a uniform-sized product for the pot trial. The collected vermicompost was kept in a covered container and maintained a moisture level at 60% throughout the storage period.

Laboratory analysis

Vermicompost and potting media

The vermicompost developed in the study was analyzed for its physical and chemical properties. The pH and electrical conductivity (EC) were determined according to the procedure described by Inbar *et al*. (1993). The total nitrogen was determined according to the Kjeldahl method (Bremner, 1960). The phosphorus, potassium, calcium, and magnesium were measured using Perkin Elmer ICP-OES after undergoing the wet digestion procedure described by Plank and Campbell (1991). The organic matter was calculated according to the 1.72 conversion factor from the total organic carbon determined according to Walkley and Black (1934). The C/N ratio was calculated from the measured values of C and N. Particle density was determined using the pycnometer method following the procedure described by Flint and Flint (2002). Bulk density and total porosity were carried out according to the column method described by Yahya *et al*. (2009) and calculated according to Inbar *et al*. (1993).

The Potting Media Trial

The potting media trial was carried out at the IOF plant nursery for three planting cycles. The size and volume of the flower pot used are 11 cm × 11cm

× 10 cm (0.95 liters). Due to their short planting cycle, the choy sum mustard (*Brassica chinensis* var. *parachinensis*) was used as the test crop. The seed was purchased from a seed production company in Puchong, Selangor. The vermicompost and soil were mixed according to the ratio presented in Table 1, and it was carried out ten days before seed sowing. Four seeds per pot were sown, and three germinated seedlings were maintained until harvest. The experimental design was a Completely Randomized Design (CRD) with three replications. The plants were irrigated daily with mist spraying. No fertilizer was added to the treatments except for T6 (control), where commercial organic liquid fertilizer derived from fish protein hydrolysate was applied.

Table 1. Treatments according to vermicompost:soil mixtures

Treatments	VC:S (v/v)
Control	0:100
T1	20:80
T2	20:60
T3	60:40
T4	80:20
T5	100:0

Harvesting, data, and sample collection

The yield and dry matter biomass of organic choy sum mustard were determined at harvest, which was at 35 days after sowing. The media sample from all treatments and replications (*n*=54) were collected in a zip-lock plastic bag and air-dried for two weeks. The plant height and number of the petiole of harvested choy sum mustard were also recorded at harvest. The dry weight of the plant was determined after samples were oven-dried at 45 °C for 72 h (Russell, 1973).

Statistical analysis

The data were subjected to the Test of Normality using Shapiro-Wilk, and one-way analysis of variance (ANOVA) using the Statistical Analysis System (SAS) software version 9.4, and the means were separated using Duncan's Multiple Range Test (DMRT) at 95% significance level (α=0.05).

RESULTS AND DISCUSSION

The initial physicochemical properties of the potting materials before mixing are shown in Table 2. Generally, the vermicompost produced was higher in nutrient concentration than clay soil. These values are closer to the proposed optimum value suggested by Edwards *et al*. (2010) and Grubinger (2012). For example, vermicompost contained 269.1 mg/kg nitrate-N, 5.6 mg/kg P, and 34.7 mg/kg K, which are higher than 21.58 mg/kg nitrate-N, 0.28 mg/kg P and 3.1 mg/kg K in the soil, respectively. The higher nutrient content in vermicompost was attributed to the high organic matter content achieved through the vermicomposting process. In addition, higher nitrate-N content compared to the proposed optimum value for potting media by Grubinger (2012) could be due to the high N content of the raw materials (Table 3). The rest of the parameters observed in Table 2 reported readings within the proposed values by Edwards *et al*. (2010), except for total porosity. According to Tjosvold (2019) and Evans (1998), the desired total porosity value for potting media is ≥ 50%, while the proposed optimum value is more than 82% (Table 2). Our data showed a percent porosity of 68% for the vermicompost. Therefore, based on the proposed value for an appropriate soil amendment and potting media product, the vermicompost produced was considered sufficient to support plant growth.

Table 2. Physicochemical properties of vermicompost

Properties	Clay soil	VC	The proposed optimum value for potting media	[c]ASEAN standards
Nitrate (mg/kg)	21.58 ± 6.45	269.1 ± 1.45	100-199[a]	
Phosphorus (mg/kg)	0.28 ± 0.06	5.6 ± 0.71	6-9[a]	> 4%
Potassium (mg/kg)	3.1 ± 0.63	34.7 ± 4.75	150-249[a]	
OM (%)	1.4 ± 0.17	32.70 ± 2.15	> 20[b]	≥ 20
C/N ratio	65.1 ± 16.17	13.4 ± 1.40	11 – 25[b]	< 25
pH	6.7 ± 0.21	7.28 ± 0.05	5.5 – 8.0[b]	4.0 – 9.0
EC (mS/cm)	0.04 ± 0.001	0.53 ± 0.03	< 1.0[b]	-
Bulk density (g/cm^3)	1.4 ± 0.04	0.67 ± 0.05	< 1.0[b]	-
Total porosity (%)	42.0 ± 1.00	68.0 ± 3.00	> 85[b]	-
Water holding capacity (%)	36.3 ± 0.42	74.0 ± 5.60	55 – 75[b]	-

The mean is expressed with standard error (*n*=3). The proposed value was adapted from [a]Grubinger (2012), [b]Edwards *et al*. (2010), and [c]Thandar *et al*. (2017).

Table 3. Selected properties of *G. sepium* and scrap paper used in vermicomposting

Parameters	*G. sepium*	Scrap paper
Total C (%)	2.0 ± 0.03	31.2 ± 0.14
Total N (%)	3.9 ± 0.02	0.10 ± 0.01
C/N ratio	0. 5	295.6

Mean is expressed with standard error (n=3)

Table 4 shows the physicochemical properties of potting media according to VC:S mix ratio and reference values for potting media. Overall, T3 (60% VC) achieved all desired properties according to the reference value, except organic matter content (14.75%). However, lower organic matter content in T3 did not affect the overall physical properties of the potting media because it has attained desired values in bulk density, total porosity, and water holding capacity (Table 3). Hazelton and Murphy (2016) described that organic matter content of more than 15% could be classified as healthy soil characteristics.

Table 4. Physicochemical properties of potting media. T1: 20% VC; T2: 40% VC, T3: 60% VC; T4:80% VC; T5:100% VC; T6: 0% VC

Properties	Ref. value	Control	T1	T2	T3	T4	T5
Nitrate (mg/kg)	40-299*	$28.0^{d} \pm 2.70$	$101.1^{cd} \pm 11.16$	$123.6^{bc} \pm 14.59$	$271.6^{a} \pm 70.18$	$204.6^{ab} \pm 22.67$	$204.4^{ab} \pm 27.85$
Phosphorus (mg/kg)	3-9*	$0.8^{c} \pm 0.09$	$1.5^{c} \pm 0.34$	$3.4^{bc} \pm 0.23$	$7.3^{a} \pm 0.27$	$5.3^{ab} \pm 1.09$	$5.6^{ab} \pm 0.71$
Potassium (mg/kg)	60-249*	$3.8^{e} \pm 0.49$	$26.4^{d} \pm 0.51$	$24.5^{d} \pm 0.83$	$60.8^{a} \pm 0.58$	$29.1^{c} \pm 1.77$	$34.7^{b} \pm 0.50$
OM (%)	> 20**	$1.38^{d} \pm 0.08$	$2.23^{cd} \pm 0.13$	$4.18^{c} \pm 0.18$	$14.75^{b} \pm 0.59$	$16.23^{b} \pm 1.13$	$26.38^{a} \pm 1.86$
C/N ratio	11 – 25**	$7.07^{b} \pm 0.91$	$7.68^{b} \pm 1.34$	$11.23^{ab} \pm 0.85$	$13.70^{a} \pm 0.75$	$12.32^{a} \pm 2.49$	$13.18^{a} \pm 1.25$
pH	> 6.8***	$6.66^{c} \pm 0.21$	$7.5^{ab} \pm 0.10$	$7.70^{a} \pm 0.13$	$7.72^{a} \pm 0.09$	$7.60^{ab} \pm 0.07$	$7.28^{b} \pm 0.05$
EC (mS/cm)	< 1.0**	$0.04^{c} \pm 0.002$	$0.19^{bc} \pm 0.04$	$0.31^{bc} \pm 0.07$	$0.51^{ab} \pm 0.18$	$0.54^{ab} \pm 0.15$	$0.82^{a} \pm 0.20$
Bulk density (g/cm^3)	< 1.0****	$1.31^{a} \pm 0.01$	$1.19^{b} \pm 0.02$	$0.91^{c} \pm 0.01$	$0.75^{d} \pm 0.01$	$0.62^{e} \pm 0.01$	$0.51^{f} \pm 0.02$
Total porosity (%)	> 50****	$45.0^{c} \pm 1.00$	$50.0^{c} \pm 4.00$	$64.0^{b} \pm 5.00$	$65.0^{b} \pm 2.00$	$72.0^{ab} \pm 6.00$	$75.0^{a} \pm 6.00$
Water holding capacity (%)	55 – 75**	$36.5^{c} \pm 0.19$	$39.1^{c} \pm 0.84$	$37.4^{c} \pm 0.37$	$59.4^{a} \pm 5.41$	$48.3^{b} \pm 0.44$	$55.6^{a} \pm 2.32$

Means followed by the same letter across treatments are not significantly different at $p \leq 0.05$ according to DMRT. The mean is expressed with standard error (n=54). Grey-colored boxes denote reading values within the reference value. Reference value was adapted from *Grubinger (2012), **Edwards *et al.* (2010), ***Oregon State University (2010), and ****Evans (1998).

Figure 1 shows the yield, biomass, plant height, and the number of choy sum mustard petiole at harvest. In terms of overall yield, T3 (43.6 g/pot), T4 (42.6 g/pot), and T5 (40.8 g/pot) were significantly higher compared to control (13.5 g/pot), T1 (20.9 g/pot) and T2 (28.9 g/pot). For plant biomass, a different trend was observed as T4 has significantly highest biomass (4.61 g/pot), followed by T5 (4.00 g/pot), T3 (3.53 g/pot), and T2 (3.39 g/pot), and T1 (2.42 g/pot) compared to control. However, all treatments with additional vermicompost have significant improvement in terms of plant biomass as compared to control. The lower plant biomass was expected to follow the fresh weight trend. A similar trend of treatments showing a significant improvement over control is observed in plant height. A significant improvement in plant height compared to control was shown by T1 (23.53 cm), T2 (26.70 cm), T3 (26.76 cm), T4 (28.24 cm), and T5 (26.53). Finally, significantly more petioles were recorded for T2 (5.86), T5 (5.83), T4 (6.13), and T3 (7.44) compared to other treatments. Nevertheless, visual judgment suggested that growth performance was according to the following sequence: T5>T4>T3>T2>T1>control (Figure 2).

Based on the weight and number of petioles at harvest, mixing 20% vermicompost in the potting media did not improve plant growth compared to control. However, mixing 60% to 80% vermicompost resulted in greater and significant improvement in reported yield at harvest. For plant biomass and height, mixing 80% vermicompost in potting media has resulted in a higher and significant increment of these parameters over control.

Improvements in the yield and biomass of the organic choy sum mustard grown in the pot were due to higher nutrient levels. A previous study by Durak *et al*. (2017) on lettuce and by Chatterjee *et al*. (2021) on bell pepper concluded that the positive effects of the vermicompost on the plant dry matter biomass, were due to an increase in soil organic carbon, nitrate-N, P and K. A similar study also proved the positive effects of vermicompost on plant dry matter biomass (Nurhidayati *et al*., 2018). Additionally, the increase in yield was also attributed to an overall improvement in the physical properties of the potting media. Manivannan *et al*. (2009) clearly stated that enhancing the physical characteristics of potting media can result in a favorable growing environment for crops, resulting in increased growth and agricultural yields.

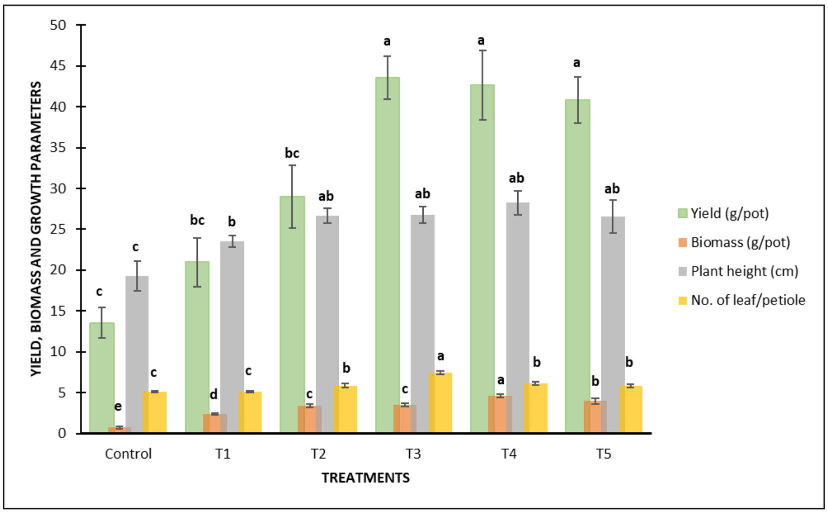

Fig. 1. Choy sum mustard yield, biomass, plant height, and the number of petioles recorded at harvest. T1: 20% VC; T2: 40% VC, T3: 60% VC; T4:80% VC; T5:100% VC; control: 0% VC. Means followed by the same letter in a similar parameter class are not significantly different at $p \leq 0.05$ according to DMRT. Error bars represent the standard error of the mean (n=54).

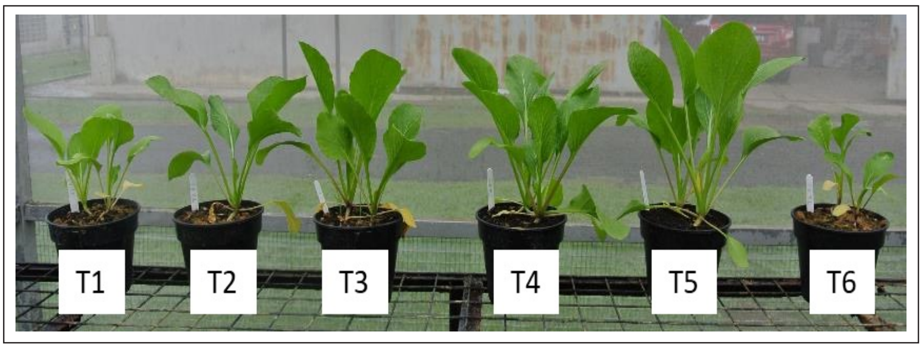

Fig. 2. Organic choy sum mustard in pot arranged according to the treatment at 35 days.

Gopalakrishnan *et al*. (2012) and Alsina *et al*. (2013) found that the best growth responses were exhibited when the vermicompost constituted a relatively small proportion (10%-40%) of the total volume of the container medium. However, our findings showed different trends with the highest fresh weight (in 60-80% vermicompost), several petioles (in 60% vermicompost), and the highest biomass in 80% vermicompost. We put forward that the nutrient level variability in the various vermicompost types, as well as different plant nutrient requirements, may cause these different findings.

CONCLUSION

This study characterized vermicompost produced from the bioconversion of *G. sepium* plant trimming residue and their utilization as media for potting plants. Our findings showed that the vermicompost significantly improved the physicochemical properties of the potting media and resulted in a tremendous increase in the yield of organic choy sum mustard. In all cases, we found no significant difference in the yield of choy sum mustard planted either in 60%, 80%, or 100% vermicompost-soil mix. Hence, we suggested that the 60:40 VC:S mixing ratio is the optimum media mixture to produce a higher yield of crops.

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