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GROWTH MEDIA DERIVED FROM SOLID WASTE FOR ORCHID *Dendrobium kingianum* CULTURE

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ABSTRACT

Food waste and diaper waste contribute to top three ranking solid wastes in Malaysia. Many studies show that urine and food waste can be used as plant fertilizer but less attention has been given to the recycling of used diaper. Therefore, this study was conducted to formulate *Dendrobium kingianum* growing media by utilizing diaper waste and selected food waste: banana peels, coffee waste and eggshells. The chemical composition in diaper waste and food waste were determined by using ICP-OES method. Biochar derived from oil palm waste, sugarcane and sawdust were tested to reduce and neutralize the high ammonium content from diaper waste. Biochar derived from oil palm waste showed the best reduction of ammonium in diaper waste. Survival and growth performance of *Dendrobium kingianum* was observed and recorded. Results show that orchid in diaper formulated growth media T3 showed the best adaptation and growth performance with highest percentage of healthy leaves and number of absorption roots within 3 weeks observation period. These results revealed that diaper waste could be recycled as orchid growing media by formulating with food waste and biochar.

Key word: Orchid cultivation, waste derived compost, diaper waste, food waste

INTRODUCTION

Disposable diaper wastes contribute to 12% of landfill waste, making it almost the same amount as the total plastic waste in Malaysia (Sheila, 2016). Diapers can be classified as hazardous waste because it has both immediate and long term negative health effects (Wambui *et al.*, 2015). It may take up to 500 years to decompose and contribute to global warming, land pollution, public health and non-renewable resource consumption. Nevertheless, a component of baby diaper, super absorbent polymer (SAP), when added into soil has been proven to enhance the water retention capacity due to its high water absorbency (Bai *et al.*, 2010). Cabbage and okra fertilized by using human urine has been shown to display better growth than those using industrial fertilizer most likely because urine contains significant levels of nitrogen (N), phosphorus (P) and potassium (K), similar to the nutrients found in the common fertilizer for plants (Akpan-Idiok *et al.*, 2012).

Orchids need proper watering, as constant wetness around the roots will cause the roots to become rotten and furthermore exposed to disease. The high water retention ability of SAP in diapers can hold moisture and nutrients and only release it when the plant itself absorbs the water. Hence, keeping orchid roots dry and preventing the roots from rot. Therefore, this important feature can be an added advantage for the formulated media as an alternative to commercial media for orchids.

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MATERIALS AND METHODS

Used disposable baby diapers with only urine from children aged below 3 years were collected from kindergarten around Kuala Terengganu. The used diapers were autoclaved at 15 atm (121°C) for 15 minutes. Diaper cores were separated and dried in the oven at 80°C. In a preliminary study, ammonia content in formulated growing media was too high (data not shown) and hence needed to be reduced before media formulation. In order to determine the optimum amount and type of biochar suitable for ammonium reduction, biochar derived from different feedstock waste such as sawdust, oil palm kernel and sugarcane were tested to treat urine sample. Firstly, urine extraction was conducted using calcium chloride dihydrate solution by collapsed or breakdown SAP due to its hydrophobic nature (Hu *et al.,* 2004). The adsorption of ammonium was then performed in a container containing 1 g of biochar and 50 ml of urine. The containers were agitated in mechanical shaker (120 r min^{-1}) at 25°C for 24 hours. The ammonium ion analysis before and after adding the biochar was used as adsorption efficiency parameter of biochar. The ammonium analysis was conducted using Dionex DX-120 ion chromatography. The adsorption efficiency of biochar was calculated according to Liew *et al.* (2017). The biochar with highest adsorption efficiency was selected for media formulation.

Orchid growing media were formulated by using diaper waste, biochar, banana peels, coffee waste and eggshells in a ratio of 1.5:1.5:1:1:1 respectively with different volumes of water added to dilute the growth media (Table 1). The water that exceeded the holding capacity of diaper was discarded. Formulated orchid growth media was then analysed by using Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) to determine mineral content and nitrogen element or to analyze nitrogen content.

Adult *Dendrobium kingianum* with average 4-5 leaves and height about 18-21cm was divided and planted on the control, T1, T2 and T3 growing media in triplicates (Table 1). The orchids were cultured under room temperature with a photoperiod of 12 h at 1500-2500 lux light intensity of white fluorescence light and sprayed approximately 5 ml of water once a day. The adaptation performance of orchid in response to the formulated media was observed after 3 weeks. The vegetative parameters such as number of leaves, texture and colour, absorption roots in media, and also the emergence of new pseudobulbs were recorded.

Significant difference between nutrient content of different diaper media were analyzed using one-way analysis of variance (ANOVA, $p \leq 0.05$) and Tukey's post-hoc test for comparison by mean values of treatment.

RESULTS

The biochar from different feedstock were tested for adsorption of ammonium ion in the urine. The best adsorption efficiency on ammonium ion was obtained from the biochar derived from oil palm waste. A negative result - 0.63 mg g^{-1} was obtained from the biochar derived from sawdust which increased the ammonium ion in urine (Table 2).

Table 1. Formulation of diaper media ratio

Treatments	Formulations (v/v)
T0 (Control)	Commercial media (charcoal, dried moss, coconut husk)
T1 (No dilution)	Diaper: biochar: banana peels: coffee waste: eggshell 1.5: 1.5: 1: 1: 1
T2 (Dilution 1:100)	Diaper: water: biochar: banana peels: coffee waste: eggshell 1.5: 150: 1.5: 1: 1: 1
T3 (Dilution 1:250)	Diaper: water: biochar: banana peels: coffee waste: eggshell 1.5: 375: 1.5: 1: 1: 1

Table 2. Adsorption efficiency of biochar on ammonium ion in the urine

Biochar	Oil palm waste	Sugarcane	Sawdust
Adsorption efficiency (mg g^{-1})	0.80	0.12	- 0.63

The nutrient contents of formulated growth media were analyzed (Table 3). Orchid's adaptation and performance within the first 3 weeks of formulated growth media was compared with control (Table 4 & Figure 1). In control, the edges of some leaves started to curl and turn yellow, only 26.67% roots adhered to the growth media. In T1 growth media, yellowish fallen leaves with dead spot tips and leaves with wrinkled and rough texture were observed. While orchids in T2 and T3 media showed better performance compared to control and T1 with high percentage of healthy leaves (101.9% and 102.67% respectively) and absorption roots (60.2% and 61.57% respectively) in Table 4. There were also some new emergence of pseudobulbs observed in T2 and T3. Nevertheless, from the overall adaptation performance, T3 performed the best among the formulated media.

DISCUSSION

Diaper waste can act as good soil amendment for orchid growth as the addition of SAP in sandy soil is known to be able to improve the physical properties of soil in terms of water-holding capacity and nutrient retention (Koupai *et al.*, 2008). Similar study by Rudzinski *et al.* (2002) revealed that SAP has a good slow release property and able to improve the utilization of fertilizer and water resource by preventing fertilizer compound and plant protection agents from being lost from root zone groundwater. Suction forces of roots allowed the plants to use the water absorbed by SAP (Wei & Durian, 2013).

Diaper wastes contain urine that has significant levels of nitrogen, phosphorus, potassium and other nutrients required by plants. Human urine has been

Table 3. Comparison of nutrient content between diaper media treatment

Nutrients	Composition (mg kg^{-1})		
	T1	T2	T3
N	13.083±1467.70^{c}	8.083±1322.47^{b}	6.450±311.93^{b}
P	1.127±61.37^{c}	1.052±75.61^{c}	0.786±44.40^{b}
K	7.287±501.82^{a}	7.027±816.38^{a}	7.392±522.11^{a}
Ca	34.440±9242.20^{b}	33.772±4433.61^{b}	40.655±2657.88^{b}
Mg	0.766±57.31^{b}	0.800±62.51^{b}	1.103±67.24^{c}
Fe	0.160±42.07^{b}	0.152±35.55^{b}	0.144±18.54^{b}
Zn	0.018±2.96^{b}	0.017±1.64^{b}	0.022±2.82^{b}
Cu	0.003±1.75^{ab}	0.004±2.59^{b}	0.005±0.70^{b}
Mn	0.019±0.91^{b}	0.019±0.95^{b}	0.059±3.18^{c}
B	0.00±0.36^{b}	0.002±0.18^{bc}	0.002±0.23^{c}

Values with different superscript letters in the same row differ significantly among the groups at $p < 0.05$.

Table 4. The adaptation performance of orchids in diaper media treatment

Diaper media treatment	Leaf			Root		Emerge of pseudobulb (young shoot)
	Number of healthy leave (%)	Colour	Texture	Number of roots absorped to media (%)	Colour	
Control	63.33^{a}	yellowish and fallen leave	droopy and withered	26.67^{a}	dry, white	absent
T1	72.77^{a}	yellowish fallen leave with brown and dead spots tips	wrinkle and rough surface	25.27 ^{a}	dry and brownish white	absent
T2	101.90^{ab}	Green	thick and turgid	60.20^{b}	greenish white	present
T3	102.67^{b}	Green	thick and turgid	61.57^{b}	greenish white	present

Values with different superscript letters in the same row differ significantly among the groups at $p < 0.05$.

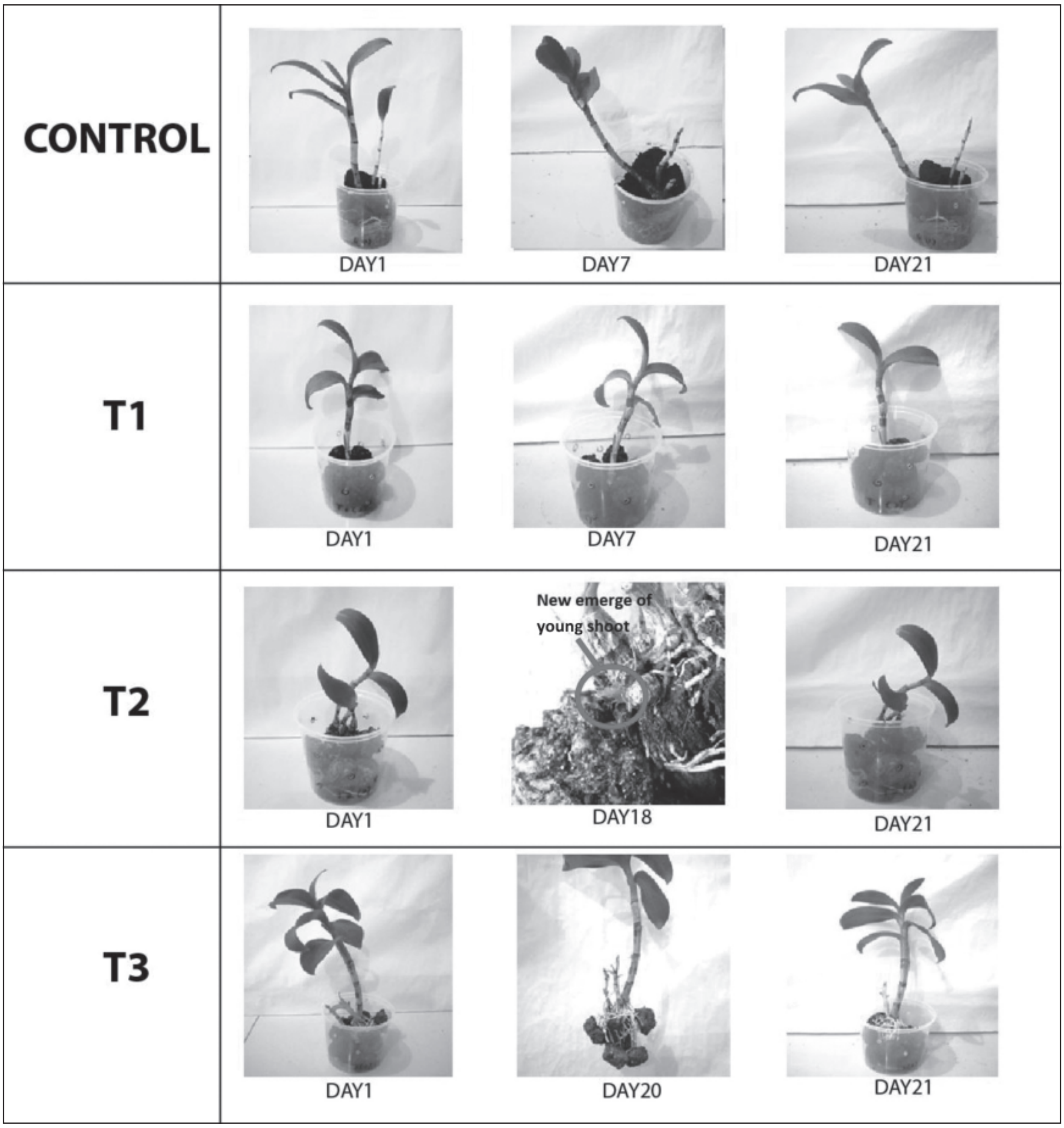

Fig. 1. Morphology observation of *Dendrobium kingianum* cultured on different type of media for 21 days.

used as fertilizer for cucumber (Heinonen-Tanski *et al.*, 2007), cabbage (Pradhan *et al.*, 2007), okra (Akpan-Idiok *et al.*, 2012) and bean (Ranasinghe *et al.*, 2016). The crops that were applied with urine fertilizers showed a higher growth rate and yield compared to industrial-fertilized crops. According to Heinonen-Tanski *et al.* (2007), the cucumbers fertilized with industrial fertilizer may have suffered a shortage of nitrogen and limited its yield while the urine fertilizer provided more nitrogen and better yield. Similarly, Pradhan *et al.* (2007) reported the growth of industrial-fertilized cabbages ceased after a certain midpoint due to the deficiency of nitrogen whereas the growth of urine-fertilized cabbages continued because of the level of readily available nitrogen in urine was in plant available forms, that is urea or ammonium (Jönsson *et al.,* 2004).

The palm oil biochar showed efficiency in ammonium reduction in the urine. Yao *et al.* (2012) found that 9 of 13 types of biochar tested positively remove ammonium with the removal rate of 0.05 mg/g to 0.79 mg/g. According to Gao *et al.* (2015), 9 types of biochars tested showed to be effective in ammonium absorption from solution with the adsorption rate of 15.8 mg/g to 17.6 mg/g. Liang *et al.* (2016) stated that the adsorption efficiency of biochar is influenced by many factors including the feedstock material, pyrolysis temperature, adsorption time, pH value and adsorption reaction temperature.

In this study, the orchid in control needs more than 21 days to adapt to the new commercial media. In T1 media, leaves turn to yellowish color, leave tips turn brown, occurrence of dead spots and leaf falling were observed. These are the symptoms of cells burn caused by accumulation of excess nutrients. Excess nutrient creates hypertonic environment to the orchid plant cell and results in dehydration. Orchids in T2 and T3 media showed higher adaptation performance. These two media showed optimum ratio of fertilizer to water retention compared to the control media and T1 media. As mentioned above, SAP in diaper possessed high absorption of nutrient and water retention ability, it hold some of the nutrients within the formulation media and release it slowly to the plant when needed.

CONCLUSION

This study represented the first work on formulation of media derived from waste material as alternative media for orchid cultivation. The media composition in T3 provided important elements for promoting plant growth and adaptation. All plants in T3 showed optimum grow with new bulb formation without application of any fertilizer for 3 weeks in constitutes. This finding contributes to an alternative for waste management and recycling of waste material that can be highly beneficial to agricultural sciences.

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