ASIAN JOURNAL OF AGRICULTURE
Volume 2, Number 2, December 2018
Pages: 39-43

E-ISSN: 2580-4537
DOI: 10.13057/asianjagric/g020201

Short Communication: Volcanic ash utilization as planting medium of curly lettuce with charcoal husk and urban waste compost as soil amendment

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Manuscript received: 26 April 2018. Revision accepted: 12 October 2018.

Abstract. *Mulyono, Maas A, Purwanto BH, Sudira P. 2018. Short Communication: Volcanic ash utilization as planting medium of curly lettuce with charcoal husk and urban waste compost as soil amendment. Asian J Agric 2: 39-43.* During a volcanic eruption, volcanic ash spreads over an extensive area and can cause environmental disturbances. Because of this, volcanic ash should be disposed of far from settlements. On the other hand, volcanic ash is useful in urban areas where pot-planting is often lacking in soil medium. However, the utilization of volcanic ash as a direct planting medium has many obstacles due to its characteristics such as the acidic, nitrogen nutrients rareness, compressed and dull to water. Hence, to be ready to use, it should be improved by using soil amendment. This study used charcoal husk combined with compost as the soil amendment. The purpose of this study was to use the volcanic ash as the planting medium, by obtaining a proper dose of volcanic ash and the soil amendments for the growth and yield of curly lettuce. The experimental design applied in this study was the completely randomized design (CRD) with three replications. The first factor was the 5 levels of charcoal husk (on volcanic ash) doses, namely 0.30; 0.40; 0.50; 0.60; and 0.70. The second was the ratio between the media and the 3 levels of urban waste compost doses, namely: 3:1; 2:1 and 1:1, resulting in 5 x 3 total combinations with three replications. The plant growth and yield data results were analyzed by using the variance analysis and continued with Duncan Multiple tests (Duncan Multiple Range Test). The results showed that when used as the sole planting medium, the volcanic ash could not support the growth of lettuce plants. The evidence was shown from the same size and weight of the curly lettuce after the age of 35 days (5 g/plant). The utilization of husk and urban waste compost treatment showed significant growth rise. The combination of volcanic ash and soil amendments showed that the best effect on the growth and yield of curly lettuce was from M3K3 treatment at the dose of 25% volcanic ash, 25% charcoal husk and 50% urban waste compost (60 g/plant).

Keywords: Charcoal husk, curly lettuce, municipal waste compost, volcanic ash

INTRODUCTION

Indonesia is susceptible to volcanic eruptions. However, one of the useful eruption products is volcanic material as it contains valuable soil nutrients. The volcanic ash layers on soil surface make the soil to experience rejuvenation and weathering process where new soil layer establishes with the help of water and organic acids. It increases the cation concentration (Ca, Mg, K and Na) in the soil, up to 50% than the original condition. Also, it functions as ameliorant that will hold nutrient supply degradation, because it contains more complete compositions, as well as neutralization power to 40% acidity which equals $CaCO_3$ (Subiksa et al. 1997; Fiantis 2006).

The use of volcanic ash as the planting medium has several constraints, which are its rapid sedimentation and hardening when exposed to water. Such conditions cause difficulty for root development, resulting in withering and death. One of the efforts to improve the physical condition of volcanic ash is by utilizing biochar, a substance with high carbon concentration. Adding biochar to the soil can increase the C concentration and water retention and improve nutrients in the soil (Lehman and Joseps 2009; Gani 2009).

Besides being used as the soil amendment material, rice husk is potentially useful in composting process and nutrition, as well as sustaining N within the composting process when added with rice husk (Theba et al. 2012). Husk characteristics include lightweight (0.20 g/cm^2), coarse (consequently, with high air circulation), high water resistance and can reduce disease influence, especially bacteria. According to Djatmiko (Purnamasari 2008) charcoal husk that is added to a planting media, will decrease the weight/volume of the planting media, rapidly increase the drainage pore space, and slowly decrease the drainage pore. Carter et al. (2013) obtained a result where the use of charcoal husk would increase the plant and root biomass, the plant weight, and the number of leaves within all plant cultivation in comparison to without charcoal husk treatment because its addition increased the soil pH and CEC (Cation Exchange Capacity).

Besides biochar, volcanic ash requires additional nutrient intake from both inorganic and organic fertilizer. This study emphasized more on the use of organic fertilizer from urban waste compost, which comes from a large number of organic wastes produced by households.

Usually, the biodegradable can be decomposed into simpler compounds due to the microbial activity (Sulistyawati and Ridwan 2012). In general, compacted waste coming from urban and rural area contains more than 75% of decomposable material, such as plant remains. The amount of decomposable waste is a quite potential source of humus, macro and micronutrient and soil conditioner (Setiyo 2007).

This study used lettuce plant (*Lactuca sativa* L.), a common consumable vegetable that is favored for salad, raw snacks, and garnish. It comes in a bright color, fine texture, and aroma that refreshes the looks of food and increases appetite. It is high source of mineral, pro-vitamin A, vitamin C and fiber (Rubatzky and Yamaguchi 1998).

MATERIALS AND METHODS

This study was carried out in the glasshouse of General Soil Laboratory, Soil Chemistry and Fertility Laboratory of the Soil Science Department, in Kuningan and Bulaksumur, Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta, Indonesia.

Materials

The planting media used was volcanic ash and charcoal husk. Volcanic ash was taken from an eruption result of Mt Kelud that fell in Yogyakarta area on 13 February 2014. Fertilizer used was organic fertilizer (urban waste compost fertilizer). As an indicator plant, lettuce was used (*Lactuca sativa* L.).

Instruments

This study used the soil chemical and plant tissue analysis as instruments, as well as the experiment instruments. The main instrument was the pot with 2 kg media by weight.

Research design

The experiment design (Table 1) applied was the *Complete Randomized Design* (CRD) with 5 x 3 and three replications. The first treatment factor was the media factor with various planting media levels (M) that included M1 (70% Volcanic ash (AV) and 30% Charcoal husk (AS)), M2 (60:40), M3 (50:50), M4 (40:60) and M5 (30:70). The second factor was the urban waste compost fertilizer dose (K) based on the comparison between media and fertilizer of K1 (3:1), K2 (2:1) and K3 (1:1), which was 15 units of total treatment. The controls applied in this study were: M01 (AV 100: AS 0%), M02 (AV 50: AS 50%), and M03 (AV 50: K 50%).

The mixing of media material and compost was carried out by using the composite method. The materials were overlaid onto plastic sheet by holding up the sheet tips and then pulling them to the center to make it homogeny and then putting the materials into the pots for planting the curly lettuce. The plant was given daily maintenance to reach 35 days of age and ready to be harvested. Watering was carried out through sprinkling system to reach field capacity.

Table 1 Experiment design

Media treatment (AV: AS)	Media: compost (3:1)	Media: Compost (2:1)	Media: Compost (1:1)
M1 (70: 30)	M1*K1	M1*K2	M1*K3
M2 (60: 40)	M2*K1	M2*K2	M2*K3
M3 (50: 50)	M3*K1	M3*K2	M3*K3
M4 (40: 60)	M4*K1	M4*K2	M4*K3
M5 (30: 70)	M5*K1	M5*K2	M5*K3

Observation variable

The variables observed in this study were classified into two groups: (i) planting media and amendment analysis variable, and (ii) plant variable. The first group included: pH, EC (Electrical Conductivity), C organic, CEC, Ca, N, P, and K total. The second included the plant height, numbers of leaf, the root weight, the fresh consumption, and the total weight.

RESULTS AND DISCUSSION

This study observed the volcanic ash feasibility to be used as vegetable planting media, especially for curly lettuce, based on the improvement of physical and chemical volcanic ash characteristics with charcoal husk amendment and urban waste compost fertilizer.

The physical and chemical analysis of the media and amendment

The Mt. Kelud volcanic ash used as the planting media in this study consisted of wrinkled silt texture dominated by silt fraction (52.24%), sand (43.81%) and a small amount of clay fraction (3.95%). The volcanic ash acidity was slightly acid and acid with undetected N content, a little amount of medium degree P, and low degree K. Also, with very low degree EC (Electrical Conductivity) and CEC volcanic ash (Table 2).

The planting media from volcanic ash was given with amendment to improve the physical and chemical characteristics. The amendment used was charcoal husk and urban waste compost fertilizer. Referring to Table 2, charcoal husk contained very low N, P, and K with neutral pH and very low EC with 5.24 cmol/kg CEC. On the other hand, the urban waste compost pH was slightly alkali, with significantly low EC, and nutrient content of 0,75% N, 0,25% P2O5, and 0,83% K. Due to the compost medium C/N ratio level, the renovation process was faster because it experienced decomposition. The compost CEC was classified as high level while the content of total N, P, and K was classified as very low level.

The plant growth and yield analysis

Based on the variance analysis and variation coefficient (Table 3), no interaction was identified between the combination of media and compost. The influence of media and amendment mixture was significantly different at all observed parameters that included the number of leaves,

the plant height, the fresh consumption weight, the fresh root weight, and the total weight. In addition, Table 4 showed the variance analysis result of each treatment of media (5 treatments) or compost (3 treatments). It was indicated that the influence of mix between media and compost was significantly different for all parameters of the plant result. In general, the best planting result was obtained from treatment M3, except for the number of leaves which was obtained from treatment M5.

Table 3. Anova Tabulation and variance coefficient between treatments

Parameters	Media	Compost	M x K	Var. Coef.
Number of leaves	NS	*	NS	11.6
Fresh consumption weight	**	**	NS	15.0
Fresh root weight	**	**	*	18.5
Total Weight	**	**	NS	14.2

Note: ** significantly different; * Significantly Different; NS insignificantly different

Table 5. The influence of treatment combination on the growth parameters (per plant)

Treatment combination	Number of leaves	Consumption weight (gram)	Root weight (gram)	Total weight (gram)
M01	5.33 (c)	3.13 (e)	1.93 (f)	5.03 (e)
M02	6.33 (c)	4.92 (e)	3.56 (ef)	8.49 (e)
M03	8.66 (b)	19.75 (d)	3.77 (efd)	23.63 (d)
M1K1	10.00 (ab)	31.49 (bc)	4.86 (cde)	36.35 (c)
M1K2	8.66 (b)	30.84 (bc)	6.46 (bc)	37.31 (c)
M1K3	10.33 (ab)	35.15 (bc)	6.10 (bc)	41.26 (c)
M2K1	9.33 (ab)	34,10 (bc)	5.04 (bcde)	39.14 (c)
M2K2	9.00 (b)	37.42 (bc)	3.77 (def)	41.20 (c)
M2K3	9.00 (b)	36.64 (bc)	7.28 (b)	43.92 (c)
M3K1	9.33 (ab)	32.42 (bc)	6.21 (bc)	38.63 (c)
M3K2	10.00 (ab)	49.49 (a)	6.19 (bc)	55.68 (ab)
M3K3	10.66 (ab)	50.38 (a)	9.44 (a)	59.82 (a)
M4K1	9.66 (ab)	33.84 (bc)	6.20 (bc)	40.04 (c)
M4K2	9.33 (ab)	38.92 (bc)	5.67 (bcde)	44.59 (c)
M4K3	10.33 (ab)	40.63 (b)	5.70 (bcde)	46.34(bc)
M5K1	10.66 (ab)	30.31 (c)	6.07 (bc)	36.39 (c)
M5K2	9.66 (ab)	34.74 (bc)	5.94 (bcd)	40.68 (c)
M5K3	11.33 (a)	39.85 (bc)	7.25 (b)	47.10 (bc)

Table 2. The physical and chemical analysis of volcanic ash, charcoal husk, and compost

Parameter (unit)		The physical/chemical characteristic value (degree)					
		Volcanic ash		Charcoal husk		Compost	
Clay	(%)	3.95	Wrinkled texture	-		-	
Silt	(%)	52.24	Silt	-		-	
Sand	(%)	43.81		-		-	
pH H2O		6.31	Slightly acid	7.07	Neutral	8.19	Slightly alkali
pH KCl		5.38	Slightly acid				
EC	(mS/cm)	0.15	Very Low	0.50	Low	0.30	Very Low
CEC	(cmol/kg)	2,74	Very Low	5.24		22.51	Low
N Total	(%)	-		0.52		0.79	
P Available	(ppm)	9.88	Medium	0.33	Total*)	0.25	Very Low
K Available	($cmol^{+}kg^{-1}$)	0.12	Low	0.96	Total*)	0.83	Very Low
C Organic	(%)			5.71		9.60	Low
Organic matter	(%)			11.42		53.90	High
C/N	-			10.98		12.15	Medium

Table 4. Variance analysis of the influence of media and compost to the plant parameter (per plant)

Parameter	M1	M2	M3	M4	M5	K1	K2	K3
Numbers of Leaf	9.66 (ab)	9.11 (b)	9.77 (ab)	10.00 (ab)	10.55 (a)	9.80 (ab)	9.33 (b)	10.33 (a)
Fresh consumption weight	32.49 (b)	36.09 (b)	44.09 (a)	37.81 (b)	34.97 (b)	32.43 (b)	38.28 (a)	40.53 (a)
Fresh root weight	5.81 (b)	5.36 (b)	7.28 (a)	5.86 (b)	6.42 (b)	5.67 (b)	5.60 (b)	7.15 (a)
Total Weight	38.30 (b)	41.42 (b)	51.38 (a)	43.66 (b)	41.39 (b)	38.11 (b)	43.89 (a)	47.69 (a)

Note: The numbers followed with the same letter in the row were insignificantly different in the DMRT 5% experiment

When observed based on the variance of single factor with combined media and compost treatment (Table 5), the control treatment of sole volcanic ash (M01) as the planting media of curly lettuce produced minimum yield amongst all treatments for all growth parameters. This was because the planting media only consisted of the volcanic ash that was solid, water dull, and with no N content that would disturb the growth and development of the plant. The addition of amendment to the volcanic ash in the form of charcoal husk with equal composition (M02) would increase the yield, although insignificantly. The addition of charcoal husk to the volcanic ash could improve the soil physical characteristics by adding porosity. However, it could not improve the macronutrient required by the plant.

The third control treatment, M03, with 1:1 composition of volcanic ash and compost, could increase the yield especially for consumption weight parameter in comparison to the other two previous treatments. This indicated that although it was not maximum, soil chemical improvement provided better results than physical improvement.

The most optimum result of curly lettuce was obtained from M3K3 combination (volcanic ash 25%, charcoal husk 25%, and compost 50%) especially for the consumption weight (50.38 gram), root weight (9.44 gram), and total weight (59.82 gram) parameters. The optimum result for the number of leaf parameters (11.33) was obtained from treatment M5K3 (volcanic ash 15%, charcoal husk 35%, and compost 50%). These results showed a relation between the composition of volcanic ash and amendment as well as its influence on the increase of planting in un-linear pattern (Figure 1). This indicated that the reduction/increase of amendment did not necessarily increase the yield.

The parameter of planting result being further analyzed was the consumption weight of the curly lettuce. Figure 1 showed the relation of media and compost to the consumption weight of the curly lettuce based on various analysis perspectives: (i) the influence of media and compost combination based on the compost treatment, (ii) the charcoal husk treatment, (iii) treatment combination, and (iv) single factor treatment. Figure 1.A. shows that the increase of compost dose generally increased the consumption weight except for treatment media M2, and the highest result was on treatment media M3. Figure 1.B showed that the increase of charcoal husk dose resulted in maximum consumption weight, especially for the compost treatment K2 and K3. The combination of treatment media and compost to the consumption weight can be fully seen in Figure 1.C. Based on the graphics, it can be wholly seen that the best consumption weight result was obtained from treatment M3K3. Moreover, such un-linearity of the influence of the amendment composition to the consumption weight is presented in Figure 1.D with equation of polynomial order-6 where the maximum result of the consumption weight was obtained from treatment M3K3.

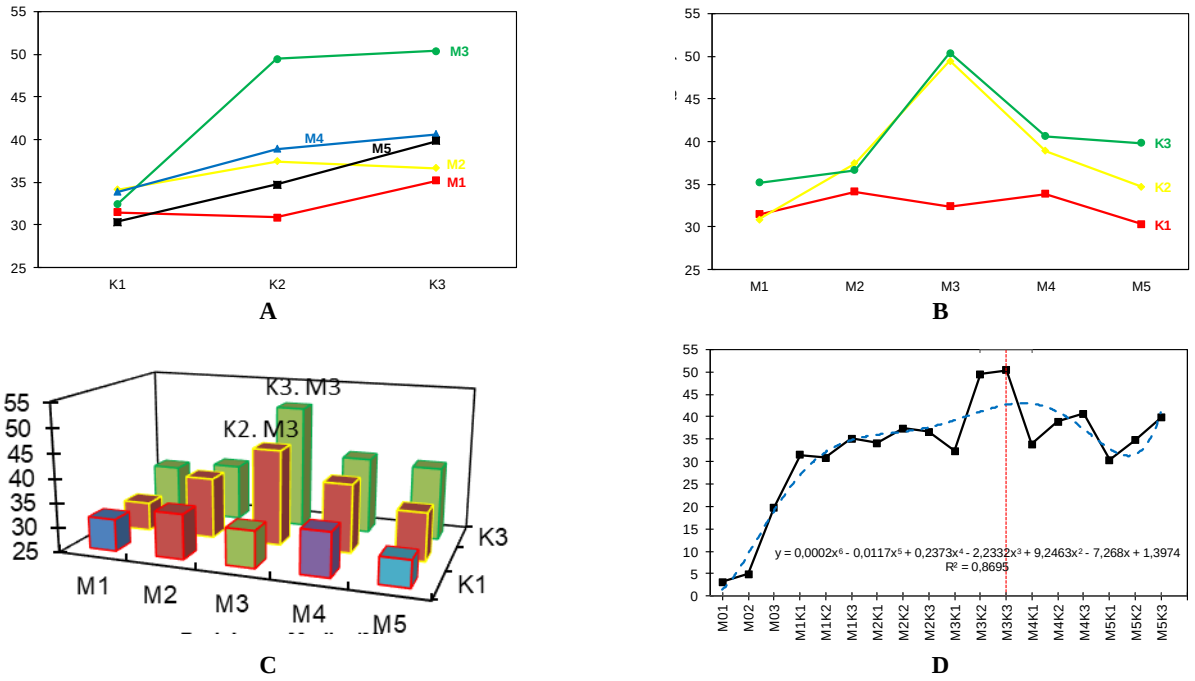

Figure 1. The analysis of the relation of the media and amendment to the planting result: A. The increase of compost dose in response to dry consumption weight (g/kg), B. The increase of charcoal husk dose in response to dry consumption weight (g/kg), C. The combination of media and compost in response to dry consumption weight (g/kg), D. The relation pattern and non-linear result of treatment in response to dry consumption weight.

In compost treatment K3, the increase of charcoal husk dose in treatment M4 and M5 decreased consumption weight relatively to treatment M3 (treatment with optimum result). This was likely because the addition of charcoal husk would increase the media porosity that the infiltration rate would also increase and give impact on the decrease of media availability to store the moisture which was essential for the plant. Such decrease of available moisture would give direct impact on the growth and development of the plant and un-optimum plating results.

In conclusion, volcanic ash with the addition of husk and compost can be used as planting media as amendment materials. Such addition could improve the soil physical and chemical characteristics. The best compost treatment obtained was K3 with M3 as the largest dose and the best treatment of charcoal husk. The relation correlation of the addition of amendment (charcoal husk and compost) to the planting result was un-linear where the best treatment was M3K3 (volcanic ash 25%, charcoal husk 25%, and compost 50%). The exceeded addition of charcoal husk in the M3K3 dose treatment decreased the planting result. This was due to the increase of charcoal husk dose that could raise the infiltration rate, consequently decreasing the media ability to store moisture and improving the growth and development of the plant. Recommendations for further study include several points: (i) with low level of N caused nonoptimum lettuce, a fertilizer with higher N is required, (ii) volcanic ash as the media should be given with larger portion than the addition of amendment (iii) the numbers of combination of media treatment is limited to M3, because the media M4 and M5 showed decreasing planting result, and (iv) it is required to measure the available moisture capacity to provide evidence on the correlation of charcoal husk dose to the infiltration rate.

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