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Research Article

The local mineral potential from East Lampung - Indonesia: the use of basalt rock as a stone meal for cassava plant

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Abstract: Indonesia has an abundant amount of basalt rocks resources, including in East Lampung Regency of Lampung Province. This basalt has not been used optimally and only be used as a foundation. The use of basalt as soil fertilizer also known as the stone meal. This study focused on the effect of using basalt dust on the growth and development of organic fertilizer application for the cassava plant. This study is to support the local government policies that declared Lampung as a national development centre of cassava, with a production rate of 30.8% of the national production of cassava. Basalt powder was characterized using test petrograph and X-ray Fluorescence (XRF) for a description of microscopic and chemical composition. The test results were used to determine the chemical composition of rock classification using the TAS diagram. The experiments of applying fertilizer on cassava crops in the demonstration plots 8 treatment x 3 repetitions were conducted by adding the percentage by weight of the basalt towards organic fertilizer between 0% (control 1), 10%, 20%, 30%, 40%, 50%, 60%, and without treatment (control 2). The results indicated that basalt from East Lampung is classified as olivine Tholeite basalt which is rich in CaO, Mg and $Na_2O + K_2O$. The growth rate of cassava plants which are affected by basalt powder presentation is characterized by a value which is higher than the value of CGR control, and recommended to not exceed 10% of the weight of basalt fertilizer.

Keywords: *basalt, cassava, fertilizer, petrograph, stone meal*

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Introduction

The use of basalt dust as a fertilizer in Indonesia is a new thing, while the potential of basalt which is used as fertilizer has been carried out abroad (Barak 1983; Knapik, 2005; Toscan and Sabedot, 2007; Haller, 2011; Jakubowski, 2013; Goreau et al., 2013; Theodoro et al., 2013; Lopes et al., 2014; Nunes et al., 2014; Bockman, 2016). The use of mineral particles as soil fertilizer, also known as a Stone Meal technique, can provide important macronutrient such as nitrogen, phosphorus, potassium, calcium, magnesium and sulfur, as well as micronutrients such as Fe, Mn, Cu, Zn and Na, to the surface of the land/ water/ soil. According to Harley and Gilkes (2000), mineral on the metamorphic rock contains the nutrients that required by plants to grow and development (Harley and Gilkes, 2000), ground rock has been proposed as a slow-release fertilizer for highly weathered soils and leaching environments where Easily soluble fertilizers may be removed. Plagioclase and orthoclase on basalt rocks are important sources of Ca and K in soils, and in some cases may be the orthoclase reviews the largest reservoir of K (Churchman et al., 2012; Noordin et al., 2017). From the literature, it is known that basalt stone meal can be used as fertilizer in a whole form of whole or in combination with other ingredients mix (Knapik, 2005; Shamsudin, 2016), in addition, the use of basalt dust on agricultural land can enhance the productivity and increased crop response (Goreau et al., 2013), some studies show the benefits of basal use including improving pH (Knapik, 2005; Theodoro and Leonardos, 2006; Nunes et al., 2014; Shafar et al., 2017), as an alternative to reduce farm costs and reduce dependence on imported raw materials while avoiding negative impacts on the environment, (Almeida et al., 2006; Fyfe et al., 2006), repairing the land cation exchange (CEC) (Shafar et al., 2017), and adding an element of K in the soil (Wang and Qi, 2007).

According to Isnugroho et al. (2018) basalt stone reserves in Indonesia Reached more than 1 billion tons. Its presence in various regions in Indonesia starts from Sumatera, Java, Kalimantan, Sulawesi, and Papua (Isnugroho et al., 2018). In Sulawesi, Zulkarnain (2001) confirmed the presence of volcanic products on Manado Tua island represent the back-side of arc volcano which consists of basalt to basaltic andesite (Zulkarnain, 2001). In Sulawesi, Zulkarnain (2001) confirmed the presence of volcanic products on Manado Tua island represent the back-side of arc volcano which consists of basalt to basaltic andesite (Ježek et al., 1981), in Sumatra Province, Zulkarnain (2001) found basalt estuary in Sipongi (Mandailing Natal, North Sumatra), and Silungkang area (Sawahlunto, West Sumatra). While in Lampung Province, Zulkarnain (2001) added that the volcanic products are spread around the west side of the mountain Tanggamus, through the bay around Semangko and continue to the east of Mount Rajabasa and basalt plateau in the Sukadana area. Zulkarnain (2001) split the area into two: the spread of western basalt volcanic rocks (Oligo up Hulu Simpang Miocene formation) and eastern volcanic rocks (from Sukadana to Tamiyang). The existence of basalt in this Sukadana also clarified by Gafoer et al. (1992) who called it a natural basalt plateau (Gafoer et al., 1992). The difference between eastern and western basalt is the level of MgO and CaO. Eastern basalt has high MgO (circa. 7% wt) and low CaO (circa. 8% wt), meanwhile the western basalt has low MgO (circa. 4% wt) and high CaO (circa. 9% wt) (Zulkarnain, 2011).

The utilization of basalt rocks in Indonesia is merely as a building material as a foundation or wall ornaments, and those which are untapped into advanced material are processed into an object that has a sale value and high benefits, such as being basalt stone meal. This study focuses on the effect of using basalt dust on the growth and development of organic fertilizer of the cassava plant. Cassava is in line with government policy that declared Lampung as cassava development of the National Center, with a production rate of 30.8% of national cassava production (BPS - Statistics Indonesia, 2019).

Materials and Methods

Basalt rock samples were obtained from East Lampung - Lampung Province - Indonesia. The basalt from East Lampung is characterized by tiny holes that are around the rock, blackish brown-skinned outside and blackish-grey coloured inside. People in this area refer to this rock as “batu keropos” and is used as a foundation material. The rock texture is rough and streaks, as shown in Figure 1.

Figure 1. Basalt from East Lampung.

According to Rajiman et al. (2018), the distribution of these rocks (mentioned in the paper as the basaltic scoria) reached 318.48 million tons and has not been explored to the maximum (Rajiman et al., 2019). The microscopic description was obtained from the Petrograph analysis while the geochemical analysis was conducted in the laboratory analysis of BPTM - LIPI using the technique of x-ray fluorescence (XRF) and x-ray defragment (XRD) to determine the mineralogical composition. The results of the XRF were used to determine the classification of basalt in TAS diagram. In addition, to determine the shape of the dust grains seen, SEM Phenomworld was used.

Fertilization experiment was conducted on plots with three repetitions, while the planting distance was 1 x 0.8 M, basalt composition was used with a range of 0% to 10% or up to 60% of the organic fertilizer weigh if there was no basalt. One plot without fertilization treatment as control is shown in Figure 2.

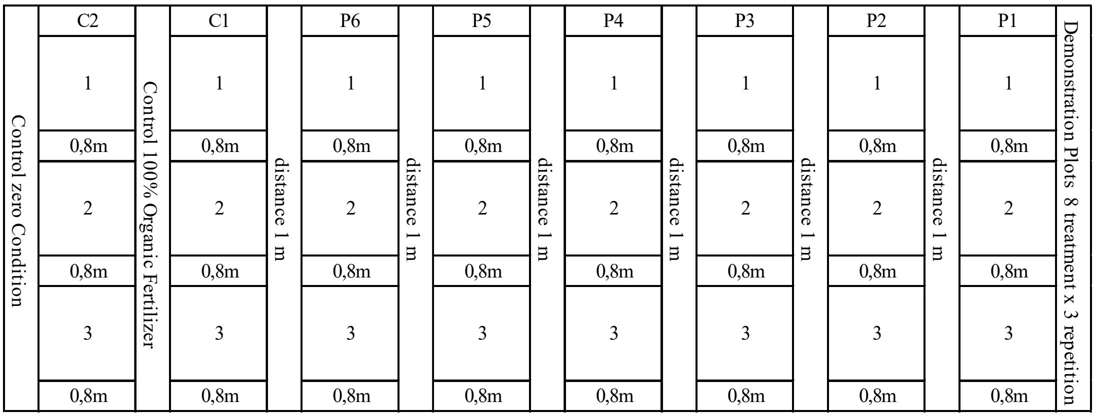

Figure 2. Disposition of casava in the experimental area.

Four different experimental plots were distinguished as P1 = 10% basalt + organic fertilizer, P2 = 20% basalt + organic fertilizer, P3 = 30% basalt + organic fertilizer, P4 = 40% basalt + organic fertilizer, P5 = 50% basalt + organic fertilizer, P6 = 60% basalt + organic fertilizer, C1 = Control 1 = 100% organic fertilizer, C2 = Control 2 = zero condition. Measurements were made of notice of plant growth calculated by the formula (Gardner et al., 1985):

$$CGR= ((G_2 - G_1))/((T_2 - T_1)) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where G is the crop growth rate and T is period. In this calculation, the ground area is not considered and the values are expressed as cm/month/plant.

Results and Discussion

The results of the petrographic analysis included studies on thin section, evaluate the content of the basalt in terms of major and trace elements.

Figure 3. Demonstration plots of 3 x 8 m.

Petrography

Petrograph analysis was conducted in the laboratory of CV Obsidian Bandung. Description of the details of the rock was tested by petrographer based on the information for petrographic analysis.

Figure 4a. Micrograph incision basalt position // -nikol.

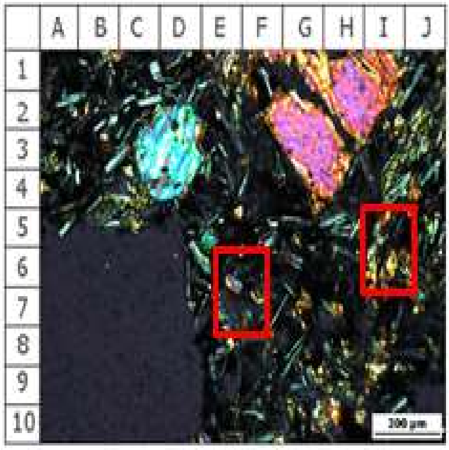

Figure 4b. The position of the X-nikol.

Based on the analysis of basalt petrograph, basalt from East Lampung is characterized by porphyritic texture and vestibular cavity at the bottom left and bottom right, there is the presence of olivine phenocrysts in the area D3; G2-3; H1-2 which embedded on a basic mass of microlite plagioclase which characterized by white colour in the lengthwise direction area A2; B2-C2; F1-2 (marked with circles); etc., (Pyroxene, and the mass of the glass, as shown in Figure 4a).

The presence of pyroxene is characterized by orange - blue – red granular on the area E6-7; H6; G9-10 (marked with the rectangular), etc., as shown in Figure 4b. Granular is located among microlith plagioclase pyroxene.

Referred to Huang (1989), pyroxene in the basalt is a provider of Ca element, while the plagioclase is an important resource of Ca, K in the soil (Churchman et al., 2012; Shafar et al., 2017). Based on the study by Gillman (1980), when this type of basalt mixed with the soil with high rainfall in tropical area such as Queensland which has been stored for 12 months in the laboratory, was able to increase the cation exchange capacity (CEC) from 9 to 14 meq / 100g, which is proportional to the rate of application and degree of fineness of the scoria, as well as to the duration of incubation. The increase in CEC is followed by a rise in exchangeable calcium, magnesium, and potassium (Gillman, 1980).

Chemical composition

The chemical composition of East Lampung basalt rock was tested using a benchtop X-Ray Fluorescence (XRF). Basalt from East Lampung has a dominant content of 38.664% Si, Fe 20.851%, 15.545% Al. The content of important macronutrient such as calcium is quite high, 13,837%, magnesium is about 3.762% and sulfur is about 0.419%, while other elements such as phosphorus and potassium are not detected.

Table 1. Chemical composition of basalt from East Lampung (BPTM - LIPI Tanjung Bintang, April 2019).

Element	Concentration	Unit	Element	Concentration	Unit
Na	3.227	%	Co	893.7	mg/kg
Mg	3.762	%	Ni	481.1	mg/kg
Al	15.545	%	Cu	233.5	mg/kg
Si	38.664	%	Zn	302	mg/kg
S	0.419	%	Ga	35.6	mg/kg
K	1.012	%	Rb	50.6	mg/kg
Ca	13.837	%	Sr	0.113	%
Ti	1.674	%	Y	25.2	mg/kg
V	521.3	mg/kg	Zr	160.2	mg/kg
Cr	0.101	%	Sn	464.2	mg/kg
M N	0,365	%	Te	144.2	mg/kg
Fe	20.851	%	Eu	431.2	mg/kg
Pb	480.2	mg/kg	Re	78.1	mg/kg

Elements of N, K, Mg, and Ca cations affect the changes in the soil. Micronutrients are found on this rock with the largest sequence covering 20.851% Fe, 3.227% 0.365% Mn, 302 mg/kg Zn, 233.5 mg/kg Cu. The low concentration of potentially toxic elements such as As, Pb, Cd, Pb and Li are only detected around 480.2 mg/kg for Pb. For proper growth, plants need essential elements such as calcium, magnesium, potassium, and phosphorus. Basaltic rock of Lampung is categorized as olivine basalt. Chemical analysis showed that the lava rocks are rich in silica and aluminous. The main chemical elements consist of 48.618% SiO_2, 18.837% Al_2O_3, 12.783% Fe_2O_3, 9.532% CaO, and other materials.

The total of CaO + MgO owned by Lampung basalt is high and comparable with other basalts which have potential as a fertilizer in the amount of 13.707%, even higher than the Rio Grande and pyroxene basalt Java. Although Na_2O + K_2O is relatively lower than basalt from Java and basalt from Brazil but still within the limits of potential as a fertilizer, which has a higher value than the basalt Bunbury is equal to 3.679%.

The weakness of basalt Lampung is that the basalt does not consist of P content, meanwhile other basalts P increase 0.62% wt. The high content of feroxide in this basalt which up to 12.783% to the basalt of Mfeusset (12.73%).

From the results of XRF, the chemical composition of basalt from Lampung has higher sulfur oxides compared with basalt and another Bunbury basalt that do not include SO_3.

Table 2. Major and trace elements analyzes of basalt from Lampung and various rocks from other sources.

Compound	Area				
	Lampung	Mfeusset (Goreau et al., 2015)	Bunbury, Western Australia (Priyono and Gilkes, 2008)	Rio Grande do Sul, Southern Brazil (Nunes et al., 2014)	Andesite pyroxene, Java (Keller, 2019)
	Content (%)				
SiO_2	48.618	46.13	47.95	63.8 - 66	55.06
CaO	9.532	9.70	11.11	2.65	8.29
Na_2O	3.061	3.37	2.1	2.65	3.09
K_2O	0.618	1.27	0.18	3.26	2.01
Al_2O_3	18.837	13.65	19.53	13.66	17.92
K_2O	0.618	1.27	0.18	3.26	2.01
CaO	9.532	9.7	11.11	2.65	8.29
TiO_2	1.277	2.83	1.76		0.36
MnO	0.204	0.22	0.16	0.19	0.5
Fe_2O_3	12.783	12.73	11.25	7.52	4.39

TAS diagram

Based on the result, it is obtained the values XRF for $Na_2O + K_2O = 3.679$ and $SiO_2 = 48.618$, so that the TAS diagram for basalt east Lampung obtained as in Figure 5. Based on Figure 6, the Na_2O / K_2O diagram (Irvine and Baragar, 1971) show the line of $K_2O + Na_2O$ is 3.061. Basalt from Lampung richer of Na_2O than K_2O. Based on the chemical composition of rocks (CaO, $Na_2O + K_2O$ and Al_2O_3), Lampung basalt is a transition between the types of Metaluminous types to Hyperluminous types.

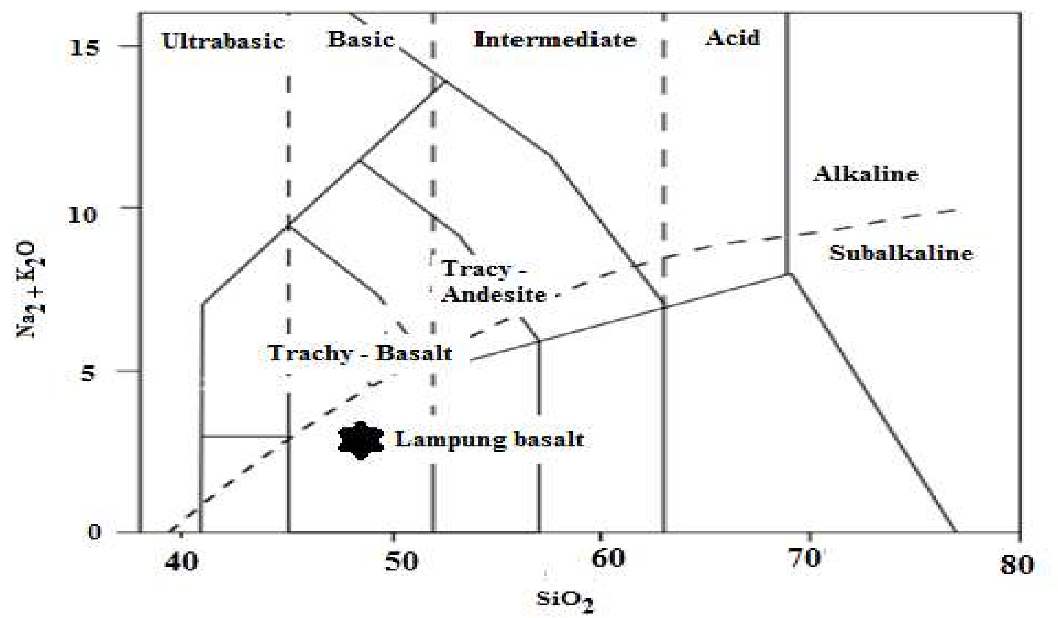

Figure 5. TAS diagram. In the TAS diagram (Figure 5), the sample analyzed located in subalkaline range.

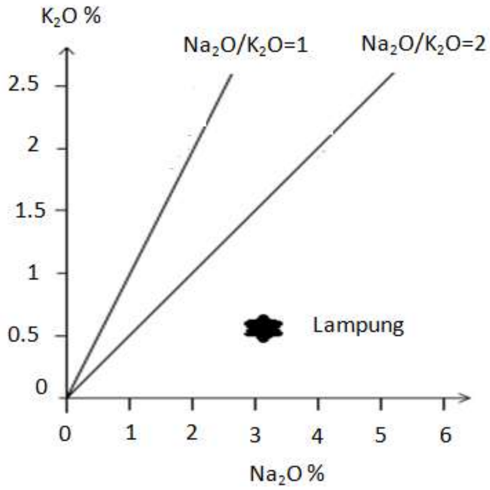

Figure 6. Na_2O / K_2O diagram of Irvine and Baragar (1971). Studied samples are richer in Na_2O than K_2O.

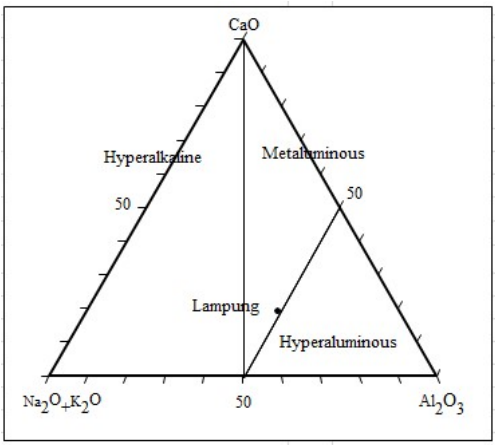

Figure 7. Diagram of metaluminous hyperaluminous vs hyperalkaline (Tchouankoue et al., 2016).

SEM and X-RD

The scanning electron microscope (SEM) - the image of the basalt powder and XRD diffractogram are presented in Figure 8 and Figure 9, respectively. Basalt powder particles have a rough surface and sub-rounded to angular shape. XRD spectrum indicates in mineralogical composition, consist of pyroxene, northite, olivine, and albite. Organic fertilizer influences the growth of cassava plant, where the average value of CGR is 7.5, whereas if untreated the averaged cassava growth is only at 7.05. The use of basalt dust gives a significant effect when using basalt CGR 10% where the value is 8.8. Figure 10 also shows a decrease in the level of CGR cassava plant, where the value of CGR is inversely proportional to the percentage of basalt dust.

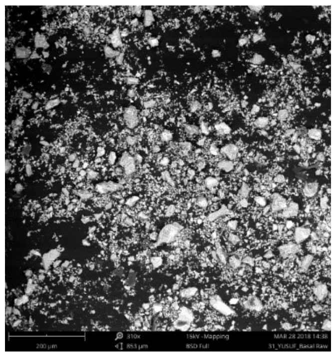

Figure 8. Scanning electron microscope image of basalt powder, FOV: 52.7 µm,
Mode: 15kV - Map, Detector: BSD Full.

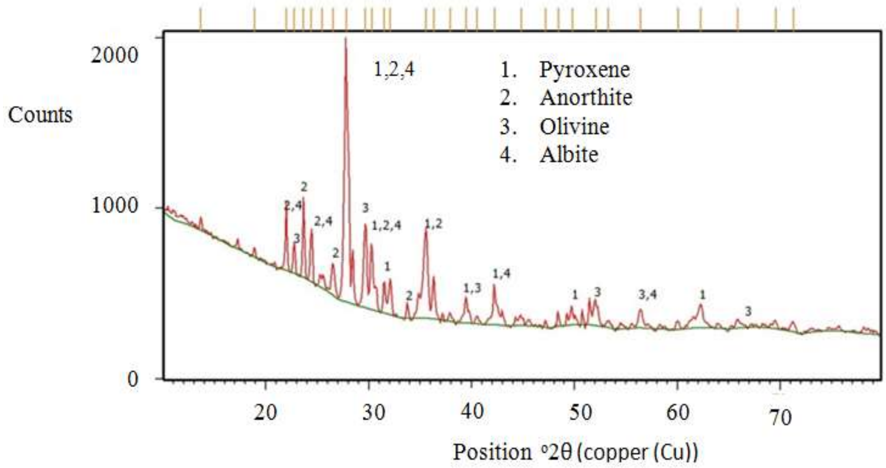

Figure 9. XRD diffractogram of the basalt powder.

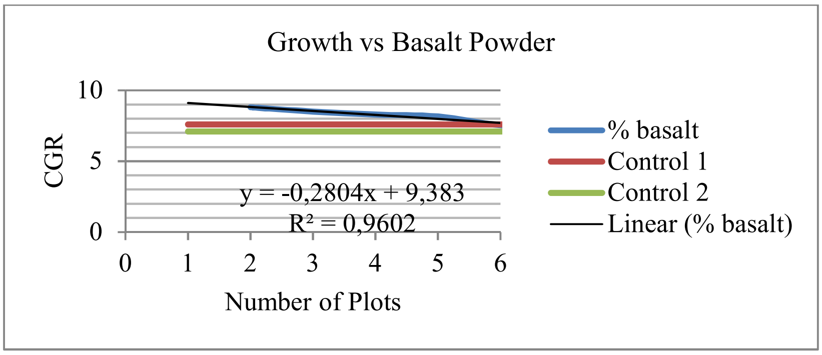

Figure 10. CGR vs concentration of basalt in fertilizer.

Conclusion

The test stone originating from East Lampung is the Sub Alkaline Thyolitic type rock. This olivine basalt characterized by the presence of olivine phenocryst which is embedded in the inner part of microlite plagioclase which is characterized by a white-coloured longitudinal direction, whereas the presence of pyroxene characterized by granular orange - blue - red. Granular located among microlith plagioclase pyroxene. Olivine basalt East Lampung has potential as a stone meal with macronutrient content such as a quite high level of calcium, 13.837% Magnesium about 3.762% and about 0.419% sulfur, while micronutrient elements covering 20.851% Fe, 3.227% 0.365% Mn, 302 mg/kg Zn, 233.5 mg/kg Cu. Dust basalt effect on plant growth is characterized by a value higher than the CGR control value, control of 0% basalt and controls without treatment. The use of basalt dust in a mixture of organic fertilizers is recommended not to exceed 10% in order to obtain a high value of CGR.

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