

The Effect of Biochar, Lime, and Compost on The Properties of Acid Sulphate Soil

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2 The Effect of Biochar, Lime, and Compost on The Properties of Acid Sulphate Soil

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ABSTRACT

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Making acid sulphate soils as paddy fields is a wise choice because it can prevent the soil from oxidizing which occurs in acidification of the soil. The use of biochar as an amendment to the land has long been known since the discovery of terra preta since 1870 in the Amazon Basin as the Amazon dark earth. Because biochar soil amendments are rich in C-organics, have a buffering capacity and can increase soil acidity, are able to absorb heavy metals, and are able to retain water and nutrients for soil organisms. Meanwhile, lime has also been known as an acid sulphate soil amendment in Rome 2000 years ago to balance the acidity in agricultural land. This has been practiced for centuries until now. Though compost or organic soil can be traced more than 2000 years ago. Soil organic matter (SOM) is formed from the remains of animals and plants. It contains C and many nutrients such as N, P, and K. Based on the description above, the author wants to combine the three ingredients in the review, especially in relation to acid sulphate soils.

Keywords: Biochar, lime, compost, acid sulphate soil

ACID SULPHATE SOIL

Indonesia has significant potential for swamp agricultural development now and in the future, but its utilization is not yet optimal (Ah & Nursyamsi, 2015). Acidic soils in Indonesia are spread between large islands, such as Kalimantan (39.42%), Sumatra (28.81%), Papua (18.03%), Java (7.77%), and Sulawesi (6.95%) (Hartatik, 2010; Masulili, 2010; Arsyad *et al.*, 2014; (Ah & Nursyamsi, 2015; Masulili, 2015; Berek, 2019). Most of them derived from volcanic rocks and old sediments under humid tropical conditions and are dominated by the Ultisols (41.92%), Inceptisols (40.89%), Oxisols (14.14%), Entisols (3.8%), and Spodosols (2.08%) (Muhrizal Sarwani, 2013; Berek, 2019). The total area of acid sulphate that has been utilized in South Kalimantan is 182,990 ha, with an area of 99,695 ha located in Barito Kuala District but only 78,209 ha have been cultivated as agricultural land

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(UNICEF, 2013; Rina & Haris, 2013; Muhammad Alwi, 2014).

Acid sulphate soils, generally have low P-availability due to the large fixation by Al, and Fe (Dent, 1986; Saleh, 2017). Some rice fields are located in these areas of soil, which not only have low pH levels (<3.5), but also contain high Al and Fe (Shazana *et al.*, 2014). Making acid sulphate soils as rice field is a wise choice because it can prevent soil from oxidation which is soil acidification process (Eka Bhakari & Hanum, 2013). Sulfuric acid in soil and sediment is formed naturally in waterlogged conditions (Wilson, 2005; Michael, 2015). Sulfide minerals that contain sulfuric acid or have the potential to transform it, can have an adverse effect (Fitzpatrick *et al.*, 2008; Michael, 2015). The soils develop due to drainage of pyrite (FeS₂) parent material (Muhrizal Sarwani, 2013; Masulili, 2015). Soils with such condition can be improved by leachate treatment, to reduce the concentration of toxic compounds such as Fe²⁺, SO₄²⁻, H⁺, and soil acidity (M. Alwi *et al.*, 2010; Ar-riza *et al.*, 2015). Acid

sulphate soil contains FeS₂ or its products and has been described as strong acidity, its ability to mobilize toxic elements and deoxygenic water systems (Michael, 2015). Cultivation plants in this soil often experience Fe²⁺ poisoning, organic acids, and H₂S (Shamshuddin *et al.*, 2013). Ferro compounds are known as Fe-poisons which can cause a decrease in rice yield of 30-100%, depending on the level of poisoning and soil fertility (Majerus *et al.*, 2007); (Ar-riza *et al.*, 2015).

Iron can be formed as oxide, sulfide, carbonate, and sulphate (Sahrawat, 2005; M Sarwani *et al.*, 2005; Majerus *et al.*, 2007; Litbang *et al.*, 2013). Iron can be dissolved through the reaction of proteolysis or reduction because of the low redox potential (Warda, 2001; Fink *et al.*, 2016; Litbang *et al.*, 2013). Iron, in principle, exists as an element in two oxidation states, Fe³⁺ and Fe²⁺, which is strongly influenced by environmental conditions (Suduan Gao *et al.*, 2002; Litbang *et al.*, 2013).

Uninterrupted underground water, acid sulphate is benign (Michael, 2015). The beginning of land damage due to oxidation of FeS₂, oxidation causes an increases in the concentration of toxic Fe²⁺ and S compounds that result in acidification of the soil (Alwi *et al.*, 2010; Ar-riza *et al.*, 2015). Iron toxicity is one of the most common problems in the lowland rice farming system, many swamps and lowlands (rainfed and irrigated lowlands or even mangrove swamps) (Chérif *et al.*, 2009; Nugraha & Rumanti, 2017). Excessive amounts of Fe in the soil and in the reduction area is common in soil solutions. This high Fe concentration is attached to the lowland soils (Becker & Asch, 2005; Chérif *et al.*, 2009), and is the result of massive input of Fe which is insoluble in runoff which is obtained from the ground at a higher altitude (Audebert & Sahrawat, 2000; Asch *et al.*, 2005; Chérif *et al.*, 2009). Oxidations that cause increased

concentrations of poisoning include drought, dug up, or exposed to air by lowering the surface of the water. Sulphides react with O to form H₂SO₄ (Mcgrath *et al.*, 1995; Nordmyr *et al.*, 2008; Michael, 2015). Digging or removing soil or sediments, lowering the surface of ground water or filing lowland soils create this acid (Department of Environment and Conservation, 2011). Oxidation that occurs in a long time will increase the acidity of the land. This condition can cause mineral lattice unsteady, thereby dissolving heavy metals like Al, Zn, and Cu (Suriadikarta, 2005; Ar-riza *et al.*, 2015). The decline in soil quality is not only due to drought, excavation, exposure to the air due to drought, but also caused by human factors when they do not conduct land management system properly and sustainably (Asir *et al.*, 2005; Abdurachman *et al.*, 2005; Las *et al.*, 2006; Dariah *et al.*, 2015). As a result, the land releases H₂SO₄ and in turn releases Fe²⁺, Fe³⁺, Al³⁺ and other potential toxic elements into soil and water system (Roos & Astrom, 2005; Nordmyr *et al.*, 2008; Ljung Björklund *et al.*, 2009; Poch *et al.*, 2009; Ljung *et al.*, 2010; Michael, 2015). After acids and toxic element are mobilized, they will cause many ecological effects (Gaviria *et al.*, 1986; Poch *et al.*, 2009; Michael, 2015).

Soil acidity is one of the limiting factors of plant growth in various places, not only in South Kalimantan, especially in Barito Kuala Regency, but also in the world. Serious problems can occur in crop cultivation in acidic soils such as Al poisoning and low P concentration (Takita *et al.*, 1999; Zheng *et al.*, 1998; Larsen *et al.*, 1998; Sujana, 2013; Ar-riza *et al.*, 2015). Stunted root growth and problem in absorption of nutrients and water are also found in many research (Jian Feng Ma *et al.*, 2000; Kochian, 1995; Suryana, 2011; Sujana, 2013; Ar-riza *et al.*, 2015). To summarize, acid sulphate soils have the characteristics that when

oxidized will lower the pH values to very acidic with negative effects including: (1) decreasing nutrient availability, (2) increasing the impact of toxic elements, (3) decreasing plant yield and affecting the function important soil biota (Sulistiyani *et al.*, 2014; Yuni Aulia Agustina, 2016).

Pyrite accumulates in stagnant soils that contain organic matter and dissolved sulphates derived from sea water. Acid sulphate soils also develop if acid production exceeds the parent material, so the pH drops to less than 4.0 (Dent, 1986; Masulili, 2015).

Acid sulphate soils react to extreme acids (pH <3.5) and contain many SO_4 , Fe^{2+} , and Al^{3+} . These actual acid sulphate soils are not suitable for agricultural crop (Annisa, 2004; Annisa & Purwanto, 2010; Hartatik, 2010; Husna, 2014; Dariah *et al.*, 2015; Hartatik *et al.*, 2015; Ar-riza *et al.*, 2015; Gomez, 2016). The high acidity of the soil which causes increased solubility of toxic elements such as Al, Fe, and Mg also due to the low base saturation (Hartatik, 2010; Ar-riza *et al.*, 2015; Gomez, 2016). Overcoming the toxic properties arising from Al can be exchanged by using pyrolysis charcoal called biochar (Goenadi, 2010; Lehmann & Joseph, 2012).

PHYSICAL, CHEMICAL AND BIOLOGICAL PROPERTIES OF SOIL SULPHATE

Soil in swamp areas can be included in large groups, namely: (1) alluvial marine soils (Sulfaquent, Sulfaquept, Hydraquent, Fluvaquent), (2) alluvial river soils Endoaquent, Endoaquept), and (3) peat soils Haplofibrhist/hemist, Sulphemist/saprist, Sulfohemist/saprist) (USDA, 2010; Haryono, 2013; USDA, 2014b).

The physical properties of soils determine many major soil processes, and the agronomic

potential of a soil. The physical, chemical, and biological properties of the soil affect the structure of the soil by providing means to unify soil aggregates. Short-term degradation of soil structure can cause a decrease in water filtration and an increase in erosion. Organic matter plays an important role in aggregation and no organic matter contributes to unstable structure of the soil (Gomez, 2016). Clay minerals influence the physical and chemical soil properties such as swelling ability. Mechanical soil resistance reflects the resistance in the soil against penetration and is related to soil compaction. This resistance increases sharply when the soil dries and related to soil bulk density (Gomez, 2016). Other parameters that reflect the nature of groundwater transmission are the infiltration rate, which is the rate of water flow through the ground surface, and hydraulic conductivity, which is the soil ability to drain water, a very sensitive parameter for groundwater content (Gomez, 2016).

BIOLOGICAL PROPERTIES OF SOIL

Earthworm activity can increase the filtration rate. It also decreases soil organic matter content due to mineralization. All soil biological properties are interconnected with physical and chemical properties of the soils. Aeration, SOM, and pH affect the activity of various microorganisms in soils which in turn carry out related reactions in C and nutrient cycle. Changes in soil properties due to management can influence biological properties in soils and their microbial activity and finally greatly enhanced soil amendments. Soil OM is a key to biological activity and fertility of the soil. Rhizosphere is most important volume of soil where the concentration of C is suitable for many microorganisms. Organic compounds released by plant roots change the chemical properties of soil and in return greatly increase

biological activity. Rhizosphere is limited space with intense interaction between plant roots with soil microorganisms. It influence plant development through the production of growth hormones, by reducing the risk of plant diseases, and by increasing nutrients availability (Gomez, 2016).

BIOCHAR

Soil cleaners nowadays use a lot of biochar (Hartatik *et al.*, 2015). Utilization of biochar as a soil ameliorant has long been done (Goenadi, 2010). Provision of biochar can maintain the availability of ground water (Anita NK, Cahyo P, 2016). Biochar has an average ground water retention capacity of 21.13% as reported Beck *et al.* 2011 in (Anita NK, Cahyo P, 2016). Biochar, which is used for a long time, does not disturb the C/N balance, is able to hold and make water and nutrients more available to plants. The leaching of N fertilizer can be significantly reduced by applying the biochar to the planting medium (Steiner, 2009; Goenadi, 2010).

Provision of biochar and OM can increase P uptake, also can increase P availability for plants (Lehmann & Rondon, 2006; Hartatik *et al.*, 2015; Chairunnisya *et al.*, 2017). Utilization of OM in the form of biochar is one of the actions to support soil C conservation (Glaser *et al.*, 2002; Okimori *et al.*, 2003; Dariah *et al.*, 2004; Ogawa *et al.*, 2006); Ogawa & Okimori, 2010). The Indonesian Biochar Association says that an important characteristic of biochar is a minimum C content of 20% (Hartatik *et al.*, 2015).

Biochar as a soil enhancer can improve plant growth by improving soil physical and biological properties (Glaser *et al.*, 2002; Lehmann *et al.*, 2003; Lehmann *et al.*, 2006; Steiner, 2009; Goenadi, 2010). Biochar in soil is a residence or habitat for soil microbes. The

increasing nutrient availability for plants is a result of biochar application which in turn can increase nutrient retention and changing soil microbial dynamics (Saleh, 2017).

Biochar application can reduce soil density, Al-dd and Fe, as well as increase soil porosity, water content, C-organic, available-P, CEC, and exchangeable-K and Ca (Steiner, 2009; Saleh, 2017). The application of biochar in agricultural soils is useful for (1) increasing the availability of nutrients (2) increasing the ability to retain nutrient and water (Glaser *et al.*, 2002; Liang *et al.*, 2006; Hartatik *et al.*, 2015) (3) creating good habitat for symbiotic microorganisms (Okimori *et al.*, 2003; Ogawa *et al.*, 2006; Ogawa & Okimori, 2010; Hartatik *et al.*, 2015) (4) increase food crop production (Sukartono *et al.*, 2011; Lehmann *et al.*, 2006; Hartatik *et al.*, 2015 and (5) reduce the rate of CO₂ emissions (Laird, 2008; Sohi *et al.*, 2010; Spokas *et al.*, 2012; Hartatik *et al.*, 2015). Biochar given to acid sulphate soils has a positive effect on crop production (Atkinson *et al.*, 2010; Spokas *et al.*, 2012; Hartatik *et al.*, 2015).

Biochar alkalization effect is recommended to increase the pH of the soil in acidic soils and provide solid OM in the long run. Raw materials and production conditions are two factors that greatly influence biochar physicochemical characteristics (Setiawati *et al.*, 2019).

Soil is largely determined by the texture and nutritional content (Goldin, 1976). Calcification of acid soils is a worldwide practice in agriculture, aims to reduce soil acidity and replenish the positive charge of the soil (Adomaitis *et al.*, 2013; Litvinovich *et al.*, 2017; Holland *et al.*, 2018; Holland *et al.*, 2019; Pavlova *et al.*, 2019).

Calcification will provide the following benefits:

1. Reduce the possibility of Mn²⁺ and Al³⁺ toxicity;
2. Increasing microbial activity;

3. Improve physical condition (soil structure);
4. Increase symbiotic N fixation by legumes;
5. Increase the delicacy of forage;
6. Provides a cheap source for Ca^{2+} and Mg^{2+} when they are lacking at lower pH;
7. Increase the availability nutrients (P and Mo with the increasing pH level at 6.0-7.0, but other micronutrients increases when pH decreases) (USDA, 1999; USDA, 2014a).

Acid sulphate soil conditions (pH 3.5) basalts are expected to dissolve faster (Shazana *et al.*, 2014). Lime ameliorant is commonly used to reduce acidity and Al toxicity in soils. Amelioration is an effective technology for improving: (a) physical properties (increasing granulation for better aeration), (b) chemical properties (reducing H, Fe, Al, and Mg ions, and increasing the availability of Mg and P), (c) biological properties (increasing microbial activity) (Koesrini *et al.*, 2015). Calcification has a beneficial effect on soil structure because it increases stability of soil structure (Quiroga *et al.*, 2017).

THE ROLE OF COMPOST ON ACID SULPHATE SOILS

Composting is the natural process of decomposition of organic material by soil microorganisms (microbes) in a warm, humid, and aerated environment. Waste is collected into piles so that heat that evolves in the process can be saved. As a result, heap temperatures can accelerate the process of degradation of the natural base that occurs slowly in organic waste that falls to the ground. The product of the process is compost or topsoil that is valuable in agriculture for the improvement of the structure and nature of soil moisture and supply plant nutrients because the compost will break down into mineral material (Dalzell *et al.*, 1987).

Soil OM has an important role in improving physical, chemical and biological properties

(Hartatik, 2010; Hartatik *et al.*, 2015). Soil OM is derived from animals and plants remains. It contains C, O, and H and various inorganic elements such as N, P, and K. Organic matter can retain a lot of water, even can adsorb up to ten times more nutrients than clay minerals. It is built and broken down in a series of processes. Due to high temperatures in tropical and subtropical areas, the rate of decomposition higher to make SOM content is lower than that of temperate region (Dalzell *et al.*, 1987).

Low level of pH soils, especially acid sulphate soils, creates the condition with low total microorganisms. Adding organic matter including organic fertilizer to rice plants stimulates microbes into the soil. The microbes in fertilizers enhance plant growth either by supplying essentials nutrients or increasing nutrient availability (Panhwar *et al.*, 2013; Shazana *et al.*, 2014; Safirzadeh *et al.*, 2019).

HISTORY AND USE OF BIOCHAR IN SULPHATE SOIL AGRICULTURE SYSTEMS

The Amazon River Basin is ignored as a site with little wealth or interest. In 1870, James Orton, an American explorer, noticed that in addition to the normally gray and acidic soil of the basin there were large areas of black and very fertile soil. Researchers were flocking to investigate the mysterious dark earth, or *terra preta* as local people known. In 1879, naturalist Herbert H. Smith concluded that "the lumpy land owes its wealth to the protection of a thousand kitchens for perhaps a thousand year". This finding, supported by the early 20th century geologist William Katzer analysis of soil composition, which was a mixture of mineral residues, charred plant material, and biodegradable organic matter – started to rotate (Orellana & International, 2012).

For many people, this is a silly idea. But for Betty J. Meggers, the famous Smithsonian archeologist has argued that despite the rice flora in the river valleys, a weak Amazonian soil might not be able to sustain the nutrients needed for complex community agriculture needs. He asserted that every village containing more than 1000 inhabitants collapse (Wayne, 2012).

This *terra preta* or biochar had been established as a soil amendment and C sequestering agent. The biochar, based on recent research findings, has the potential for liming with a good pH buffering capacity, so that it has the potential to improve soil acidity. The biochar is also an adsorbent for removing heavy metals or pollutants, and has the capacity to retain water and nutrients, a characteristic that has the potential to reduce the problem of leaching very acidic tropical soils, as well as being a source of nutrients for plant growth. Being a safe habitat for the soil microbial community. Designated as a C sequestration agent, and reducing the emission of greenhouse gases, making it to become a climate change mitigation tool. The beneficial effect of the use of biochar on acid soils has attracted the attention of researchers around the world and research findings are formulated to be a government policy in several countries (DeLuca *et al.*, 2019). The names of the researchers are as follows:

1. Gao and DeLuca (2016), states that: The number papers published annually about biochar has increased exponentially over the past 20 years.
2. Lehmann and Joseph, (2015), states that: Biochar is produced for soil amendments, while charcoal is generally produced as an energy carrier.
3. Brown *et al.* (2015), states that: Biochar can be made from a various material including forest and plant residues, community solid waste, or even biosolids.

4. DeLuca *et al.* (2015b), states that: The characteristics of biochar can also change the hydrological nature of the soil and subsequently affect the transformation of soil nutrients.
5. Atkinson *et al.* (2010), states that: Biochar is a new topic of interest in science.
6. DeLuca and Aplet, (2008), states that: Biochar is a stable, C-rich material produced from pyrolysis of organic matter in an O-limited environment under controlled conditions and differs from charcoal produced during forest fires.
7. Lehmann *et al.* (2006), states that: Biochar is rich in nature-C combined with its unique resistance to decomposition has made it as a way of mitigating climate change when applied to soils.

In spite of the fact that the term biochar was only introduced in nowadays, the initial idea in using charcoal for agricultural purposes has been around for centuries. Amazon dark earth or *terra preta* soil found in the Amazon River Basin was reported to have been founded by native people thousands of year ago. However, it remains as the most fertile and biodiversity-rich soils in the area (DeLuca *et al.*, 2019). The response of soil scientists to the origin of terra preta is unclear and some assumes as below:

1. Glaser and Birk (2012), states that: The charcoal remaining in this soil makes it unlikely that it is a product of burning biomass in slash and burn agriculture. However, it is not clear whether biochar application on purposes or a means of sanitary management in populated areas.
2. Olarieta *et al.* (2011), states that: It shows that an ancient method named *foreigner*, a structure that similar to a charcoal furnace, was used in the Mediterranean area to make soil fertilizing material with dry wood until the 1960s.

3. Ogawa and Okimori, (2010), states that: Pioneer works on the application of biochar in agriculture were in combination with composting has been proven to have been carried out by Japanese farmers since the early twentieth century.
4. Nishio, (1996), states that: Farmers use rice husk and other agricultural residues to produce charcoal using soil furnaces and use it mostly as soil improvement or odor absorber.
5. Saito (1990), states that: Investigation insight into the beneficial effects of biochar on soils received little attention by Japanese scientists until the early 1980s.

Several papers discussing the use of biochar in agricultural ecosystems (DeLuca *et al.*, 2019) can be seen as below:

1. He *et al.* (2017), states that: Management of greenhouse gases and emissions.
2. Nguyen *et al.* (2017), states that: Soil fertility and management of soil nutrients.
3. Griffin *et al.* (2017), states that: Productivity in plant.
4. Jones *et al.* (2012), states that: Productivity in plant.
5. Lehmann *et al.* (2006), states that: Storage and absorption of C in soils.

The application of biochar in agriculture is a challenge given the variable and possible long-term benefits of biochar. The biochar production distributed by low-tech pyrolysis kilns can increase the attractiveness of biochar to agriculture which produces a small amount of biochar using local resources. This quick production method has been reported to have low greenhouse gas emissions and is widely used in many small scale agricultural (Cornelissen *et al.*, 2016; H DeLuca, 2016; Si Gao & Deluca, 2016; Si Gao *et al.*, 2017; Pandit *et al.*, 2017; Si Gao & Deluca, 2018; Hagemann *et al.*, 2018; DeLuca *et al.*, 2019).

Biochar application in agricultural soils can cause interactions that affect the physical properties such as soil porosity, water holding capacity, bulk density, aggregation, and drainage (Lehmann & Joseph, 2012; DeLuca *et al.*, 2019).

The biochar is very porous and has a large surface area, porosity, and storage capacity of water or nutrients when added to the soil as the research statements about adding biochar to the soil (DeLuca *et al.*, 2019) as follow:

1. Du *et al.* (2017), states that: Observed an increase in soil macro-aggregate stability with increasing black charcoal doses.
2. Liu *et al.* (2017a), states that: Reported 17% increase in soil porosity and a 28% increase in groundwater capacity from silt clay farming after the application of corn black charcoal.
3. Liu *et al.* (2017a), states that: Reduced bulk density mediated by black charcoal can reduce soil compaction and possibly promotion of plant growth.
4. Wang *et al.* (2017a), states that: Reported a significant increase in the stability of wet aggregate (126% and 217%) in silt clay soils after the application of walnut shell charcoal or softwood black charcoal.
5. Agegnehu *et al.* (2016a), states that: The addition of black charcoal to the soil leads to the creation of aggregate bridges and empty spaces, therefore reducing soil density.
6. Głab *et al.* (2016), states that: The application of wheat straw biochar increased the total porosity of agricultural soils, with the most increasing volume being in small pores (diameter <50µm). Changes in soil porosity are also reflected in water retention investigated with finer black charcoal which results in an increase in water holding capacity.

7. Jones *et al.* (2011b), states that: The addition of black charcoal to the soil leads to the creation of aggregate bridges and empty spaces, therefore reducing soil density.
8. Ulyett *et al.* (2014), states that: Black charcoal has also been reported to increase water retention by 1.3% in clay soils.

HISTORY OF LIME USE IN ACID SULPHATE SOIL

Lime was used by the Romans 2000 years ago to neutralize the acidity on agricultural land and has been practiced for centuries (Goulding, 2016). Liming of acid soils is a worldwide practice in agriculture (Adomaitis *et al.*, 2013; Litvinovich *et al.*, 2017; Holland *et al.*, 2018; Pavlova *et al.*, 2019) and aims to reduce soil acidity (Pavlova *et al.*, 2019).

Calcification is common management practice and has long been used to maintain optimal pH for crop production. The opinions of the research experts regarding the use of lime in acid sulphate soils are shown (Holland *et al.*, 2019) as below

1. Nguyen *et al.* (2017) states that: Soil fertility and nutrient management.
2. Goulding, (2015) states that: Calcification is a common management practice and has long been used to maintain soil pH for crop yields.
3. Tunney *et al.* (2010) states that: Liming is needed for the availability of good nutrients and plant growth in acid soils.
4. Farhoodi and Coventry, (2008) states that: Previous studies successfully quantified the relationship between soil pH and yield of some fertile plants.
5. Liu *et al.* (2004) states that: Previous studies successfully quantified the relationship between soil pH and yield of some fertile plants.

6. Cifu *et al.*, (2004) states that: Most plants are fertile, there is a positive crop response associated with liming. However, there are differences between plants in yield response to lime.
7. Cifu *et al.*, (2004) states that: Depending on the source of lime, the application can increase Mg^{2+} relative to Ca^{2+} .
8. Chambers and Garwood, (1998) states that: Lime affects the chemical properties of the soil. For example, a decrease in exchangeable-Ca and estimated $CaCO_3$ losses have been estimated.
9. Slattery and Coventry, (1993), states that: Previous studies successfully quantified the relationship between soil pH and yield of some fertile plants.
10. Haynes, (1982), states that: Calcification changes P availability and this has implications for P uptake of plants after the application.
11. Bolton, (1977), states that: Lime affects the chemical properties of the soil. For example, a decrease in exchangeable-Ca and estimated $CaCO_3$ losses have been estimated.

Application of GML (Ground Magnesium Limestone), basalts and biological fertilizers significantly increases plant height, leaf chlorophyll content and rice yield. This might be an effect resulting from an increase in soil pH which reduces the toxicity of Al and Fe (Mardi and Pheng S.K, 2007; Panhwar *et al.*, 2016).

HISTORY OF THE USE OF COMPOST IN SULPHATE SOIL AGRICULTURE

Organic waste composting has been practiced for centuries by farmers in many parts of the world (Dalzell *et al.*, 1987). Research relating to soil organic fractions can be traced back more than 200 years (Murphy, 2014). Composting is

the decomposition process of organic material by microorganisms in a warm, humid, and well aerated condition. Waste is collected together into a pile. As a result, the temperature rises and accelerate the degradation of the natural base which usually occurs slowly. The final product of this process is compost or topsoil that is valuable to improve the structure and soil moisture retention and even to supply plant nutrient when compost is finally broken down into minerals (Dalzell *et al.*, 1987).

The properties of soil that are affected by compost have been classified into three major groups: biological, chemical, and physical properties. It should be noted that three are strong interactions and interdependencies between these groups. For example, the ability of compost to multivalent chelate can influence its potential to stabilize soil structure and also its biodegradability (Cork *et al.*, 2012; Murphy, 2014; Ibrahim *et al.*, 2019). Compost is important in soil productivity and quality and greatly influences the physical, chemical, and biological processes of the soil. It is one of the main soil properties that control nutrients in agricultural production systems and is an index of soil productivity (Ibrahim *et al.*, 2019). Soil OM is formed from animals and plant remains. It contains C, O, and H and many inorganic elements such as N, P, and K. Organic matter can retain a lot of moisture and adsorbs more nutrients than clay minerals. Because of high temperatures in tropical and subtropical areas, the rate of loss of SOM is high and it is difficult to maintain (Dalzell *et al.*, 1987; Ibrahim *et al.*, 2019).

CONCLUSIONS

Biochar alkalization effect is recommended to increase the pH of the soil in acidic soils and provide solid OM in the long run and have the capacity to retain water and nutrients and

become a habitat for soil organisms. Lime as acid amendments can control acidity on agricultural land and its use has been practiced for centuries and continues to the present day. Calcification of acid soils can reduce the acidity to the soil and replenish the positive charge of the soil. Compost is important in soil productivity and quality and greatly influences the physical, chemical, and biological processes of the soil. It is one of the main soil properties that control nutrients in agricultural production systems and is an index of soil productivity.

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