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ASSESSMENT OF MICRONUTRIENT (Fe, Cu AND Mn) CONCENTRATIONS IN SOIL FROM CACAO PLANTATION COASTAL AREAS, EAST LUWU REGENCY

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ABSTRACT

Micronutrients Fe, Cu and Mn, despite being required in only small amount, have an important role in cacao plant metabolism. This study aims to assess of micronutrient (Fe, Cu and Mn) concentrations in soil from cacao plantation coastal areas, East Luwu Regency. Availability of micronutrient (Fe, Cu and Mn) were analyzed by dry ash method and measured with Inductively Coupled Plasma (ICP). The results showed that Iron (Fe) was represented in large quantities (788.80 mg/100 g). Copper (Cu) and Manganase (Mn) were represented in small quantities 21.65, and 4.34 mg/100 g, respectively.

Keywords: Soil, Micronutrients, Coastal

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1. INTRODUCTION

Cacao plantations in Indonesia have experienced rapid development in the last 20 years. In 2015 the total area of cacao plantations in Indonesia was 1.72 million ha. Distribution of the main cacao centers is in Sulawesi and Sumatera. South Sulawesi is ranked second as the main cacao center with a contribution of 16.59%. East Luwu is one of the districts in South Sulawesi which became the center of cacao with production of 10,222 tons in 2014 [1]. One type of land used as a cacao farm is land in the coastal area. In the context of the ecological approach, coastal areas are defined as land areas that are still influenced by the processes and dynamics of the sea [2]. The characteristics of land on the coast are having a mineral content that is difficult to decay relatively higher than easily decayed minerals, and generally this soil is rich in mineral types such as pyrite (FeS_2) and kaolinitic minerals, especially quartz (SiO_2) [3].

Land as a place to grow cacao plants has an important role as a source of macro and micronutrients. Macronutrients include nitrogen (N), phosphorus (P), and potassium (K), calcium (Ca), magnesium (Mg). While micronutrients include iron (Fe), copper (Cu), and manganese (Mn). Even micronutrients are needed only in small quantities but have an important role in plant metabolism. In plants, Fe is found to be around 80% in photosynthetic cells which have an important role to play in the biosynthesis of cytochrome and other heme molecules [4] . Copper in plants has several important roles including as a structural element in the regulation of proteins, as electron transport in photosynthesis, and regulating cell wall metabolism [5]. The most important role of Mn in plants is closely related to the oxidation-reduction process. Species of Mn^{2+} ions are known as specific components of two enzymes, arginase and phosphotransferase which have important roles in plant metabolism [6]. Cacao as one of the leading commodities is a source of nutrition that is rich in essential minerals, both macro and micronutrients which can contribute to the body's nutritional needed [7]. As in any other plant food, the mineral content of cacao reflects the soil in which it is grown. With this in mind, this study aims to determine the availability of micronutrients namely iron (Fe), copper (Cu), and Manganese (Mn) in coastal cacao plantations in East Luwu Regency.

2. MATERIAL AND METHOD

Sampling Method and Preparation of Cacao Farm Soil

Soil samples were taken from cacao plantations in Bubuh Hamlet, East Luwu. Soil samples were collected at five sampling points randomly using the transect lines model [8]. Samples were taken at a depth of 10 cm. Then the samples were dried in an oven at 70 °C for 24 hours, milled with porcelain mortar and sieved with a 100 mesh sieve [9].

Analysis using ICP-OES

One gram of sample in a crucible was placed in a preheated muffle furnace at 200–250 °C for 30 min, and then ashed for 4 h at 480 °C. Then, the sample was removed from the furnace and cooled down; 2 ml of 5 M HNO_3 was added and evaporated to dryness. Next, the sample was placed in a cool furnace and heated to 400 °C for 15 min, before being removed (from the furnace, cooled and moistened with four drops of distilled water). Next, 2 ml of concentrated HCl was added and the sample was evaporated to dryness, removed, and then 5 mL of 2 M HCl was added and the tube was again swirled. The solution was filtered through Whatman No. 42 filter paper and then transferred quantitatively to a 25 mL volumetric flask by adding distilled water [10]. The micro nutrient content is determined using Inductively Coupled Plasma (ICP).

3. RESULT AND DISCUSSION

The availability of micronutrients in a soil is inseparable from the weathering process of the primary rock. Two stages are involved in this process, the first is the change in the constituents of primary rock minerals by weathering physical and chemical processes. In the second stage, pedogenic results in the formation of soil profiles from weathered rock material, which leads to the development of mature zonal soils as the end point of interacting processes. Weathering and pedogenic processes are not easily differentiated and separated because they can occur simultaneously and are interrelated. Chemical weathering can be described as a process of dissolution, hydration, hydrolysis, oxidation, reduction, and carbonation. All of these processes are based on enthalpy and entropy rules, and they lead to the formation of relatively stable and balanced mineral and chemical components in certain soil environments [6]. Availability micronutrient of iron (Fe), copper (Cu), and manganese (Mn) in coastal cacao plantations in East Luwu Regency is shown in Table 1.

Micronutrient formation reactions in weathering processes in a particular environment are significantly different. While the mobility of the elements during the weathering process is determined by the stability of the parent minerals and the electrochemical properties of the elements. The availability of micronutrients mobilized by mineral dissolution depends on the properties of ionic species formed in soil solutions and regulated by a system of chemical variables in the soil. The chemical variable systems are like changes in species transformation which include: (1) electron transfer reactions, (2) ligand exchange reactions, (3) organometallic reactions, and (4) biotransformation [11].

Among some pedogenetic forms of Fe, abundant forms of minerals are goethite (α-FeOOH) and hematite (α-Fe_2O_3) in well-drained soils. Other forms of Fe oxide which may be present in small amounts in poorly drained soils are crystalline minerals (lepidocrocite, maghemite, and magnetite) [12]. Factors that play a role as a regulator of the availability of Fe in the soil include redox potential and pH. In neutral pH conditions increase the precipitation of Fe minerals so that their availability becomes small, while in reduced and acid conditions encourage mobilization of Fe minerals in the soil [13]. In this study the average iron (Fe) content in coastal areas of cacao plantations was 788.80 mg/100 g.

In the [6] lists the range of Fe content (mg/100 g) in several plant species: (1) vegetables: range 3.3 to 6.5, lowest value for celery root, and highest for spinach; (2) cereals: range 3.1 to 9.8, lowest value for wheat, grains, highest for barley; and (3) beans: range 1.5 to 6.5, lowest value for almonds and highest for soybean seeds. Based on data variations of Fe requirements in the above plants, it can be seen that the Fe content in coastal plantations can meet the micronutrient requirements of plants.

Manganese originates from primary rocks which are generally in the form of ferromagnetite. Mn elements derived from these rocks are released through the weathering process of primary minerals and will unite with O_2, CO_2 and SiO_2 to form secondary minerals mainly into pyrolusite (MnO_2) and Manganite ($MnO(OH)_2$), hausmanit (Mn_3O_4), rhodocrocytes ($MnCO_3$) and rhodonite ($MnSiO_3$). High Mn content is often reported on soils above mafic rocks, soils rich in Fe or organic matter, and soils in dry regions or semi-arid [6]. In this study the average Mn content in coastal cacao

Table 1. Micronutrients content (Fe, Mn, Cu) in mg/100 g

Element	Sampling Points				
	Point 1	**Point 2**	**Point 3**	**Point 4**	**Point 5**
Fe	874.25	624.25	953.50	762.00	730.00
Mn	21.54	21.63	18.52	23.98	22.61
Cu	4.07	2.24	4.35	6.15	4.90

plantation area was 21.65 mg/100 g. In the [6] contained Mn content (mg/100 g) in plants around the world ranging from 1.7 to 33.4 on grass and from 2.5 to 11.9 on cloverleaf, food crops are also reported to contain varying amounts of Mn, the highest in beetroot (3.6–11.3) and lowest in apples (0.13–0.15). Rate of critical Mn deficiency For most plants it ranges from 1.5 to 2.5 mg/100 g, while the concentration of Mn poisons for plants varies more depending on plant and soil factors. In general, most plants will be affected by Mn content above 40 mg/100 g [6]. Based on data on the range of Mn content in the various types of plants above, it can be seen that the Mn content can meet nutrient requirements in plants.

There are several forms of Cu minerals, the main mineral form being simple and complex sulfides. This mineral is quite easy to dissolve in the weathering process and releases Cu ions, especially in acidic environments [11]. The form of the mineral is chalcopyrite, $CuFeS_2$; bornit, Cu_5FeS_4; calcolite, Cu_2S; and kovelit, CuS. Copper is also often associated with sphalerite minerals, ZnS; pyrite, FeS; and galena, PbS. The deposits are generally found in acid igneous rocks and various sediment deposits [14]. In this study the average copper (Cu) content in coastal areas of cacao plantations was 4.34 mg/100 g. In the [6] lists a range of Cu content (mg/100 g) in several types of plants: (1) vegetables: range 0.1–3.2, lowest value for celery roots, and highest for garlic cloves; (2) fruits: range 0.3-4.0, lowest value for grapes, and highest for avocados, skinless; (3) cereals: range from 0.3 to 13.0, the lowest value for wheat, as a whole, and the highest for rye, as a whole; and (4) peanuts: a range of 0.2–23.8, the lowest value for fresh coconut meat, and the highest for Brazil nuts peeled. Based on the data on the range of Cu content in the above plants, it can be seen that the Cu content in coastal plantations can meet the micronutrient requirements of plants.

4. CONCLUSIONS

Micronutrient average content of Fe, Cu, and Mn in coastal cacao plantations in East Luwu Regency were 788.80; 21.65; 4.34 mg/100 g, respectively. When compared with the worldwide contents of each micronutrient in plants, the availability of cacao plantations in coastal areas in East Luwu Regency can supply those needs.

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