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Utilization of Extract Tailings and Cow Manure for Increasing of Soil Quality and Uptake of Micronutrients of *Xanthosoma sagittifolium* (L.) Schott on Sub Optimal Land of Wondama

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ABSTRACT

Xanthosoma sagittifolium (L.) Schott has a great potential to be developed as alternative food, particularly for local Papua people. Taro plants that grow in Teluk Wondama regency, generally can grow in mineral soil with less nutrients and high rain fall, so the nutrient tend to be low due to the wipe of the rain water. The low available nutrients need to be improved by applying integrated nutrient management through the addition of enzymatic nutrient from tailing extract and amelioration of organic matters from livestock manure. Study findings indicated that tailing extract containing micronutrient Cu, Fe, Mn, and Zn can be utilized as nutrition and enzymatic nutrients source that plays a role in electronic transport and as catalyst and activator of enzymatic reactions. The test of optimum fertilizer formula in Taro seeding indicated that organic fertilizer enriched by tailing extract at composition of A2 (95% : 5%) significantly increased the growth of Taro seeding. The sequence of micro nutrient absorption level, which was stated in coefficient of transfer value from soil to Taro was Zn>Cu>Mn>Fe.

Keywords: *Micronutrient, Taro, transfer coefficient, manure, tailing.*

INTRODUCTION

Taro plants are one of the important staple foods for local Papua people, but recently the position of Taro plants begin to be displaced by sweet potato Rumawas, 2004[1] and imported rice. Taro is a semi-aquatic submerged plant even though it is usually referred to as upland taro[2]. Taro plants growing in Regency of Wondama Bay commonly grow in suboptimal land with less nutrients, and with high rainfall that reduce the available nutrients. The application of balanced fertilizing concept by utilizing tailing extract and livestock manure as enzymatic nutrient source and ameliorant in the mineral soil, will increase the plant growth and quality of Taro tuber. Solid manure, or livestock manure in solid form that have been composed as nutrient source, particularly N for plant and can improve the chemistry, biology, and physics of the soil.

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Tailing waste present in tailing sedimentation area ModADA and ADA, is included in the contract area of PT Freeport Indonesia (PTFI), with total area of 45.000 Ha [3]. The tailing waste contains macro and micro nutrients with great potentials as plant nutrients which can be utilized as nutrition in agriculture widely. According to the results of nutrient status analysis for the tailing material derived from sedimentation area of ModADA, the N status is low, whereas the P, K, Mg, Zn and B are classified as fairly marginal. The nutrients of Ca, Fe, Cu, Mn, Mo and Ni are categorized as enough[4-8].

This study was aimed to increase the production in quantity and quality of Taro tuber growing in suboptimal land through the application of formulated fertilizer from tailing extract as nutrient and enzymatic nutrient source, and livestock manure as ameliorant material.

MATERIALS AND METHOD

Analysis of Soil Properties

The soil samples from the study area of Wondama

Bay were collected of representatives site. The soil samples were dried and crushed, and then passed through on 2 mm sieve to be used in determination characteristics of chemical and physical of soil fertility status by analysis of samples in Soil Laboratory. The analysis of chemical properties include of pH (Piper, 1967), C-organic, Walkley & Black,[9] Total-N (Kjeldah method), P-available (Bray I), Base cations (Ca^{2+}, Mg^{2+}, K^+, Na^+), CEC (NH_4 OAc, pH 7), and also base saturation (BS), Al $^{3+}$ and H^+. The analysis of phusical properties include of texture (sand, silt, and clay).

The treatment method of Extracted Tailing (referring to previous research by Mangallo et al.[4]

The first step was the extraction of macro and micro nutrients from tailing source as enzymatic nutrient source for Taro plant growth. The tailing sample was extracted with extraction method as follow: Incubation with HCl 2% for 24 hours with soil to solvent ration 1:10. The result was then incubated with ammonium citrate 2% for 24 hours and then filtered. The macro nutrient and enzymatic nutrient contained in the tailing extract were analyzed by the instrument of AAS.

RESULTS AND DISCUSSION

Fertility status, Chemical and Physical Properties of Baseline Soil in Wondama

The chemical and physical properties of baseline soil at the depth of 0-20 cm in study location, Wondama, West Papua, was presented in Figure 1. Soil reaction (pH) ranged from 4.7 - 5.0 (highly aciditic and aciditic), C-organic content 1.99 - 2.16%, C-organic (low - moderate), total-N was 0.28 - 0.29%, N (moderate), with C/N ratio of 7 (low). Low ratio of C/N means that the organic matter have been decayed and decomposed, whereas high C/N ratio means the decomposition process of organic matter is in progress.

There is a significant correlation between % BS and soil reaction (pH). A decrease in BS will be followed by a decrease in pH value. Decerasing of BS is generally caused by loss of calcium (Ca^{2+}) or other base cations (Mg^{2+}, K^+, Na^+). Consequently, the soil pH also decreases because the base cations are replaced by hydrogen (H^+) and aluminium (Al^{3+}). Base cations of Ca^{2+} and Na^+ were low, at the level of 2.99-5.99 cmol/kg and 0.22-0.28 cmol/kg, respectively, whereas Mg^{2+} was moderate (1.34-1.84 cmol/kg), and K^+ was very high (1.08-2.12 cmol/kg). Acid cations (Al^{3+}, H^+) were in relatively low to moderate concentration (0.71-1.34 me/100g and 0.06-1.33 me/100g). Low pH value tended to cause the BS percentage varied from medium to high (49.43%-70.52%). Base saturation (BS) and pH were highly influenced by CEC. When CEC was high due to the domination of base cations (Ca^{2+}, Mg^{2+}, K^+, Na^+) in the soil, the BS percentage was also high.

According to the physical properties of the soil, most of the studied location land were dominated by sand particle ((47.2% - 54.7%), followed by silt particle (25% - 28.5%), and clay particle (21.3% - 25.8%). Value of CEC is highly determined by organic colloid contained in organic matter of soil, and clay colloid derived from secondary clay mineral as the result of decomposition of primary mineral decays easily. Overall, the CEC value was very low, ranging from 12.29-14.10 cmol/kg. This condition as the cause of low-medium C-organic content, as well as the clay particle.

According chemical and physical properties in study location, Wondama was classified as Inceptisol[10]. Inceptisol is a young soil, but more developed compared to entisol. This type of soil shows the layering and soil structure have been formed, and the available nutrient elements are adequate. Inceptisol is newly developed soil type and have had horizon below the characterizer. The type of soil has essential nutrient reserve needed for plant growth from the easily decayed mineral.

The treatment combination of fertilizer formula to the availability of micro-nutrients in soil

The treatment of combined formulated fertilizer at different compositions was intended to study the chemical characteristics of the soil and macro or micro nutrients availability required by the plant to grow.

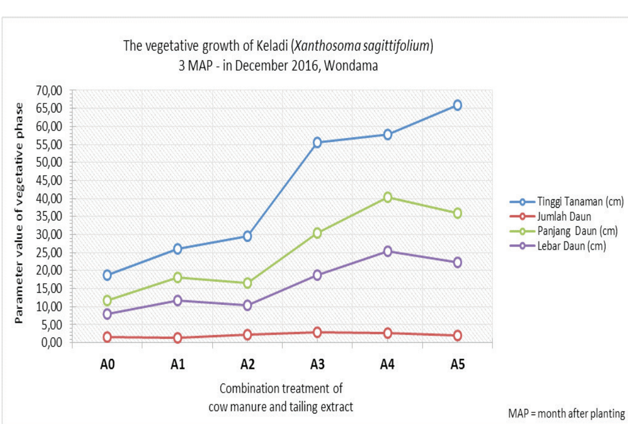
Micronutrients are essensial elements needed by plants in very small quantities[11,12]. The availability of micro nutrients (Fe^{2+}, Mn^{2+}, Cu^{2+}, Zn^{2+}) in the soil in study location indicated that Mn^{2+} level remained within normal level, whereas Cu^{2+} and Zn^{2+} were in low concentration, so they positioned in critical threshold for plant growth need[13]. However, after the application of formulated fertilizer when plant reached the age of 2 MAP (month after planting), the need of micro nutrient increased compared to before planting.

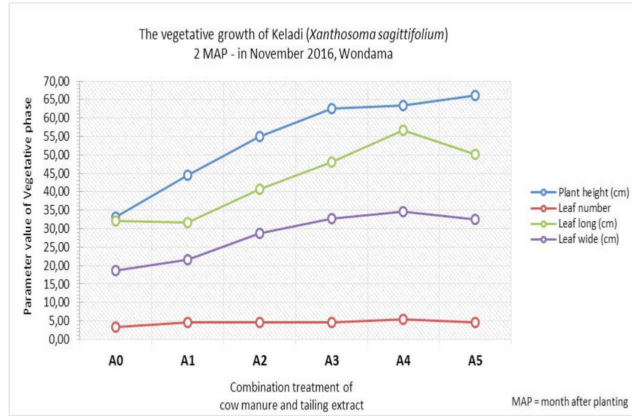
Soil reaction (pH) significantly affected the solubility and availability of nutrients and phytotoxicity potensial of a metal. Soil solution at low pH favors the free metal cation and anion protonation, whereas high pH favors the formation of carbonate or hydroxyl complex. Therefore, the availability of micro nutrients and toxic ions in soil solution as cations will increase with the increased soil acidity. Conversely, the availability of anion nutrients will increase with the increase of alkalinity. However, when the soil solution is dominated by metal cations with equal charge, the Fe^{2+} will be easily available compared to Mn^{2+}, because the mobile properties in Mn^{2+} which is available later than the Fe^{2+}.

The treatment combination of fertilizer formula to the avalability of micro-nutrients (Fe^{2+}, Mn^{2+}, Cu^{2+}, Zn^{2+}) in plant tissue of Xanthosoma sagittifolium

The vegetative growth of Taro plant during three months of observation included the parameters of plant height (cm), number of leafs, length of leafs (cm), and width of leafs (cm). The application of combined fertilizer formula at different compositions to study the vegetative growth of plant at age 1-3 MAP (month after planting) is presented in Figure 3-5.

The treatment with combined formulated fertilizer included A0, A1, A2, A3, A4, and A5. The observed variables during the vegetative stages included plant height, number of leafs, length of leafs, and width of leafs. For the treatment of combined formulated fertilizer A1 and A2, the plant growth showed an increase during vegetative stage and reached optimum growth in A3, whereas for the treatment without combined formulated fertilizer (A0, Control) the plant growth was very slow during the vegetative stage. The vegetative growth tended to decrease in A4 and A5. This is due to N, P, K and C-organic nutrients contained in the formulated fertilizer had met fulfilled the plant need during vegetative growth stage.





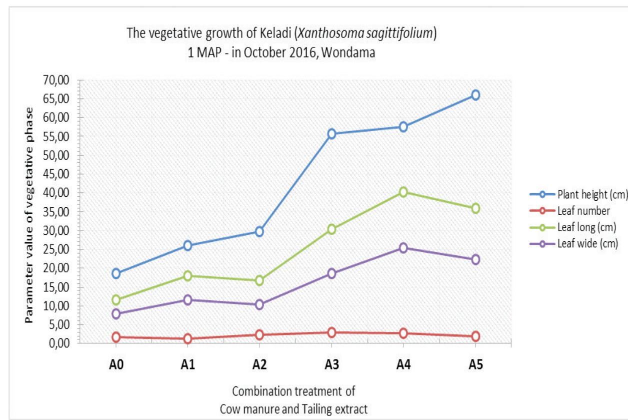


Figure 1,2,3. The vegetative growth of Xanthosoma sigittifolium at 1 - 3 MAP on Suboptimal Land of Wondama

Carbon, oxygen, and hydrogen are precursors in the development of plant body tissues, which can be obtained in the form of H_2O (water), H_2CO_3 (Carbonic acid), and CO_2 from the air. According to initial data on soil fertility status in studi location, it was observed that base cations Mg^{2+} and K^+ is inversely proportional Ca^{2+} and Na^+. This phenomenon is frequently found in mineral soils with lower pH (acid). In addition, cations with equal valences (+2 or +1) in soil solution tended to have competition in occupying space, resulting in higher level for one compared to the other.

With the application of formulated fertilizers, it can be seen that vegetative growth of the Taro plant can fulfill its macro nutrient need from cow manure, and its micro nutrients from tailing extract. Figure shows that the application of combined formulated fertilizers A3 is the optimum condition for vegetative growth of Taro plants.

Transfer Coefficient of Micro Nutrient from the Soil to Taro plant

Iron acts as a catalyst in the formation of chlorophyll as well as an oxygen carrier in the nodules of legumes[14]. Study results indicated that the value of transfer coefficient for iron transfer from soil to Taro plant ranges from 1.00 to 1.59, with the following sequence A2>A0>A1>A4>A5> A3. The lower transfer coefficient value for iron compared to other micro nutrients (Zn, Cu, Mn) is affected by the characteristics of the iron as immobile mineral Monreal *et al.,*[15] and antagonist to other micro nutrients, particularly Mn. To reduce the effect, we can use organic matter as chelating agent to stabilize the iron ions.

According to Havlin *et al*[16] the manganese adequacy in plant is 20-500 ppm. This indicated that the treatment with formulated fertilizers in all combinations can fulfill the adequacy of manganese nutrients in Taro plant.

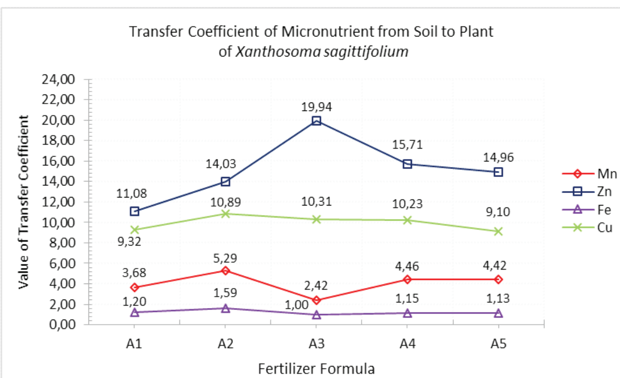


Figure 4. Transfer Coefficient of Micronutrient from soil to plant of *Xanthosoma sagittifolium*

Copper is an activator of several enzyme systems in plant and plays a role in the formation of chlorophyll. Transfer coefficient value of copper mineral from the soil to Taro plant ranged from 8.03 to 10.98 with the sequence: A2>A3>A4>A1>A5>A0. The concentration of copper in Taro plant with treatment of formulated fertilizer in all combination was 5-20 ppm, indicating that the application of formulated fertilizer in all combination could not fulfill the Cu adequacy for Taro plant.

Zinc is a micro nutrient highly required by the plant. Zinc plays a role as enzymatic metal component or as functional and structural cofactor of most enzymes[15]. Transfer coefficient value of zinc is 6.90-19.94 with the following sequence A3 > A4 > A5 > A2 > A1 > A0. However, unlike the other metal ions such as copper, iron, and manganese, zinc is a divalent cation (Zn^{2+}) without valence change and therefore it does not have redox activity in a plant. This affect the absorption of Zn^{2+} from the soil to the plant, so the transfer coefficient value of Zn was higher compared to micro nutrients Cu, Mn, and Fe. The high absorption of Zn is also affected by the lower concentration of divalent cation such as Ca^{2+} in the soil[17]. Zinc concentration in Taro plant with the treatment of formulated fertilizers in all combination ranged between 17.4-47.49 ppm.

CONCLUSIONS

Combination of formulated fertilizers A1 and A2 indicated increased plant growth during vegetative stage and reached optimum growth in A3, whereas the plants without treatment (A0, control) the growth was very slow. The vegetative growth tended to decrease in A4 and A5. The optimum formulated fertilizer in Taro seedlings indicated that formulated organic fertilizer had been enriched with tailing extract in composition A2 (95% : 5%) and significantly can increase the Taro seedlings growth. The sequence of micro nutrient absorption level as expressed by transfer coefficient value from the soil to plant was Zn > Cu > Mn > Fe. The lower concentration of divalent cation, namely Ca^{2+} in the plant influenced the Zn^{2+} absorption level.

Ethical Clearance: Obtained from University of Papua

Conflict of Interest : None

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