Beneficial Effect of Local Resources to Improve Food Crop Production in Tidal Swamp of Indonesia

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Abstract— *Soil found in tidal swamp, Indonesia is dominated by acid sulfate soil. This soil is very acidic resulting in infertile soil for plant growth. This soil is also found in large distribution in South Sumatra, Indonesia with low food crop production. This acidic soil is shown in low content of nutrient and organic matter causing farmers should supply fertilizer in large quantity to support plant growth. Due to increasing price of inorganic fertilizers, farmers are difficulty to purchase the conventional fertilizer. To overcome this problem, it can be introduced some local organic resources such as agricultural wastes to supply nutrient for plant growth or applying for indigenous microorganism to increase nutrient problem. To that respect, this paper will discuss about the organic local resources to improve food crop growth such rice and corn planted in acid sulfate soil. The organic materials analysed used were composted rice straw, cow bone powder, cattle slurry, cow blood powder, ash rice straw and additional anorganic materials used like natural rock phosphate and zeolite. Highest content of N, P and K elements released from organic materials were found in cow blood powder with value of 6.51% N, 1.69% P and 0.125% K respectively followed by cow slurry and humic acid substances of composted rice straw. Furthermore, zeolite contained K, Ca and Mg amounting to 1.28% K, 3.39 % Ca and 0.85% Mg, whereas rock phosphate has Ca content amounting to 20.15% and Mg 2.68%. These materials both organic and anorganic substances were prepared for raw material as a solid organic fertilizer. The composition of solid organic fertilized combined with mineral fertilizers consisted of 45% Humic Acid (HA) + 30% Conventional Fertilizer (CF = 4N:2P:1K) + 25% Natural Material (NM) with a dosage of 750 ton/ha provided the best growth of paddy rice with highest yield of 6.12 ton/ha for Ciherang variety. Meanwhile liquid fertilizer with composition of gliricidia leaves, bamboo shoots, banana weevil, maja fruit, bananas and coconuts water with the rate of 10 l /ha yielding 5.92 ton rice/ha. Moreover, application of 1000 ml POME combined with 10% zeolite produced 5.05 ton/ha corn.*

Keywords— acid sulfate soil, cow blood and bone powder, organic fertilizer, paddy rice, humic acid.

I. INTRODUCTION

Indonesia has more 22 milion ha of tidal swamp, from which about 9.53 million ha acid potential soils, 6.71 million ha acid sulfate soils, 5.89 million ha peatland and 0.44 million ha salin soils. About 4.19 million ha of acid potential soils have been reclaimed for agriculture and transmigration destination and the rest of 5.34 million ha is still be used as agricultural development (Tim Sintesis Kebijakan, 2008). This tidal swamp is usually used for cultivation of paddy soil because in this condition pyrite will be stable in anaerobic condition (Hairani et al., 2005). The tidal swamp area is characterized by poor chemical properties and deep water level. The poor chemical properties include low soil pH and high in Fe and Al concentration. Combination of high rainfall and effect tidal movement make this area have excessive water in a certain period in the year (Purnomo et al., 2006), specially in area which has not been reclaimed.

Generally this tidal swamp in Indonesia is used as destination of transmigratin program of Indonesian Government that is directed to Sumatra, Kalimantan and Papua, from the people who are come from Java Island who have no experience to occupy in tidal condition. Beside, the problem of soil fertility for plant growth, the situation of these soils in tidal swamp are commonly bad in infrastructure and no economic institution to get daily needs for the people lived in these areas and the availability of fresh water. People are difficult to get their daily need. However, now palm oil plantation is developed on this tidal soil and people can work in the palm oil company, thus they will get income for their life, because they can't expect the income derived from food crop production.

II. SOIL PROBLEMS IN TIDAL SWAMP

The main problem of soil in tidal swamp is acidic soil due to pyrite material exposure to soil surface contacting with oxygen from the air. If it is pyrite in anaerobic condition, pyrite will be stable and it is not releasing H^+ to become acidic. Actually, farmers did not know about this mechanism resulting in exposuring pyrite to the soil surface causing pH down to very acid

caused by decreasing water table. The soils will have pH about < 3.5 and containing Sulfate ions, Fe^{2+} dan Aluminum (Al^{3+}). This soil is called actual acid soils (Dent, 1986; Suradikarta, 2005). An acidic condition usually develops due to oxidation of the sulfidic materials (e.g. Iron Sulfides) in these soils. Elements such as iron and aluminum are released to soil solution in large amount, while essential nutrients like phosphorus and nitrogen become fixed in the soil resulting in unavailable for plant growth (Dublien-Green and Ojanuga, 1988).

Acid sulfate soils with pH below 3.5 will have toxicities of H^+, Al^{3+}, SO_4^{2-} and Fe^{3+} causing in decreasing soil fertility due to low soil bases and essential macro nutrients such as P, K, Ca, Mg (Hairani et al., 2005) and low essential micro element such as Mn, Zn, Cu and Mo (Fahmi and Hanudin, 2008). Due to low fertility faced in acid sulfate soils causing food crops cannot grow optimal in these condition with low production (Hairani et al., 2005). Nursanti (2014) analysed that acid sulfate soil taken from Jambi has low pH with value of 4.10 resulting in low macro elements such as C, N, P, K, Ca and Mg with respectively values of 1.76%, 0.18%,14 mg kg^{-1}, 0.40 (cmol(+)kg^{-1}), 1.08 (cmol(+)kg^{-1}) and 1.30 (cmol(+)kg^{-1}) (Table 1). Ristiani (2012) reported that soil taken from acid sulfate soil from Telang of Banyuasin Regency has also low pH with value of 4.10 in combination with very low of earth alkali with value of 1.30 Cmol(+)/kg Ca and 0.28 Camol(+)/kg Mg. In this infertile soil, food crop will produce in low quantity. Thus, this soil should be improved the fertility in order to food crop will grow properly.

TABEL 1
SOIL CHARACTERISTIC TAKEN FROM TIDAL SWAMP (NURSANTI, 2014)

No	Variabels	Values	Criteria *)
1	pH H2O (1:1)	4.10	Veru acidic
2	C-organic (%)	1.76	Low
3	N-total (%)	0.18	Low
4	C/N	9.78	Low
5	P Bray I (mg kg^{-1})	14.30	Low
6	Ca-exch (cmol(+)kg^{-1})	1.08	Very low
7	Mg-exch (cmol(+)kg^{-1})	1.30	Moderate
8	Na-exch (cmol(+)kg^{-1})	0.98	High
9	K-exch (cmol(+)kg^{-1})	0.47	Moderate
10	H-exch (cmol(+)kg^{-1})	1.38	Low
11	CEC (cmol(+)kg^{-1})	15.24	Low
12	Al-exch (cmol(+)kg^{-1})	4.34	
13	Al- saturation (%)	45.45	High
14	Base saturation (%)	25.13	Low
15	Particle distribution : Sand (%) Silt (%) Caly (%)	 0.34 39.07 60.59	

III. SUGGESTED SOLUTION

Using local sources to improve soil fertility such as composted rice straw, cow bone powder, cattle slurry, cow blood powder, ash rice straw and POME (Palm oil mill efluent), and additional anorganic materials such as rock phosphate and zeolite should be suggested. Syafrullah (2012) reported that highest content of N, P and K were found in cow blood powder with value of 6.51% N, 1.69% P and 0.125% K respectively followed by cow slurry (2.22% N, 0.31% P and 0.125 %K) and humic acid substances of composted rice straw with values of N, P and K of 1.260, 0.44% and 0.25%. Furthermore, zeolite contained K, Ca and Mg amounting to 1.28% K, 3.39 % Ca and 0.85% Mg, whereas rock phosphate has Ca content with value of 20.15% and Mg 2.68%. Nursanti (2014) stated that POME has varied value depending on the degree of

decomposition, and the highest content of N, P, K were obtained in acidic pond amounting to 0.27% N, 0.09% P and 0.10% K but the pH is very low with value of 4.77, meanwhile in anaerobic condition with pH of 6.1 contained N, P and K about 0.18%, 0.07% and 0.06% respectively. Syafrulah (2013) found that application of solid organic material with dosage of 750 kg/ha for Gogo Aromatic variety planted in acidic sulfate soil gave highest yield with value of 7.04 ton/ha, and Nursanti (2014) reported that application of 1000 ml POME taken from secondary anaerbic pond in combination with zeolite at dosage of 10% has given the best soil fertility of acid sulfate soil as shown by stability macro aggregate, water holding capacity, base saturation, Al saturation, CEC, P Bray and total N. The zeolite combined with POME increased adaptability of maize to dry condition and improved soil fertility and increased growth and yield of maise.

Budianta et al (2012) has shown that application of liquid organic fertilizer (LOF) preparing from local resources collected from farming area such as gliricidia leaves, bamboo shoots, banana weevil , maja fruit, bananas and coconuts water with the rate of 10 l /ha yielding 5.92 ton rice/ha (Table 2). Moreover, It was found about 6 indigenous of genus bacteria in acid sulfate soil from South Kalimantan which were *Burkholderia sp*, *Nitrospira sp*, *Streptomyces sp*, *Raistoni sp*, *Microbacterium* and *Curtobacterium* under local food crops such local rice, tuber Siam (Hairani et al.m 2005). These microorganisms can be developed to increase P availability in acid sulfate soil. The sequence capability of microorganism to dissolve unavailability AlP_4 is Burkholderiales followed by Actinomycetes and Nitrospirales ordes (Hairani et al., 2005).

TABLE 2
EFFECT OF LIQUID FERTILIZER ON GROWTH AND YIELD OF RICE (BUDIANTA ET AL., 2012)

Treatment LOF	Plant height (cm)	Number of tillers (steam)	Productive tillers (steam)	grains per panicle (grain)	Production per m^2 (kg)
LOFo	100.75 a	27.02 a	21.57 b	114.86 c	2.50 a
LOF1	101.12 a	28.55 a	23.13 a	127.53 b	2.58 a
LOF2	101.68 a	28.57 a	23.98 a	134.97 a	3.06 a
Lsd 0.05	3.05	1.56	1.32	2.82	0.38

Note = Figures followed by the same letter means no significant
LOFo = no liquid organic fertilizer added
LOF1 = LOF derived from salam and wedusan leaves, banana weevil and the coconut fibre
LOF2 = LOF derived from gliricidia leaves, bamboo shoots, banana weevil, maja fruit, bananas and coconuts water

IV. CONCLUSION

Local resources derived from agricultural wastes have potential to be used for improvement soil fertility and plant growth in acid sulfate soil. Application of solid organic fertilizer and liquid fertilizer can improve food crop growth such as rice and corn planted in unfertile soil of tidal swamp. This potential of local resources is very useful for farmer to replace inorganic fertilizer with high price which is not affordable by the farmers. The main beneficial effect of organic fertilizer applied to farming system can be maintaining soil quality and soil health, thus food crop produced is very safe for animal and human consumed that crops.

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