DIVERSITY OF SOIL MICROBIAL ON TIDAL LAND AND THE POTENTIAL OF UTILIZATION FOR SWEET POTATO CULTIVATION

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ABSTRACT

The analytical descriptive study was conducted to observe the biological status of tidal land in South Kalimantan. The soil sample was taken before and after the sweet potato has reached 45 days after planting (dap). The variety of sweet potato used is the local variety UBI, with 7 treatments of organic and/or inorganic fertilizers application. The results showed that tidal area of South Kalimantan has low soil microbial populations (<103 cfu/g of soil), with high diversity level. By planting microbial culture on selective media, the beneficial microbes found included non-symbiotic nitrogen-fixing bacteria and phosphate solubilizing bacteria and fungi. The calculation of root infection rate by vesicular-arbuscular mycorrhizae reaches >55% with spores' amount around 178 spores/g of soil. The total population of soil microbes increased after 45 days the sweet potato planting (reached 10^6-10^8 cfu/g of soil). This change occurred by the interaction between the physical properties of soil at the time of the soil tillage, the chemical properties of soil upon application of fertilizers, and the biological properties of soil after the growth of the sweet potato plant. The increase in total population of soil microbes indicates the potential for microbial utilization of beneficial microbes. The success of this research will complete several previous researches that review the physical and chemical aspect of soil, in order to get better results in increasing sweet potato plants productivity and environmental sustainability.

Keywords: soil microbial diversity, potential of tidal land utilization, sweet potato cultivation

Introduction

Soil quality is determined by three aspects of soil quality indicators, covering: physical aspect, chemical aspect, and biological aspect (Doran and Zeiss, 2000). The interaction of the elements of these three aspects will play an important function in creating soil ecosystem stability, ensure the availability of nutrients for plants, as well as plant growth regulator (Gupta and Yeates, 1997). Mastery of the physical aspect and chemical aspect of tidal land in Indonesia has been quite a lot, lately started to do research the biological aspect, though not yet well integrated.

Determining the biological status of land requires precision and patience in the assessment, because the substance is alive, dynamic and may change in the space of time. The dynamic nature of the soil biological aspects gives great opportunities in management (Loreau *et al*, 2001). Understanding the quality of the soil should be viewed holistically on the physical, chemical and biological environment to create arable and ecological land. Soil quality was defined as a soil's ability to function as an ecosystem boundaries in sustaining biological productivity, maintain environmental quality and improve the health of plants and animals (Doran and Parkin, 1994; Stenberg, 1999).

The aim of this study was to determine the biological status of tidal land. Biological parameters studied were the total population of soil microbes, beneficial microbe species diversity, and changes in soil microbial community structure by the use of fertilizers and planting of sweet potatoes on tidal land of South Kalimantan, the success of this study will provide hope in the biological management of tidal land for sweet potato cultivation through local knowledge, based on ecological and economical.

MATERIALS AND METHODS

The study was conducted in two (2) locations, namely in Sidomulyo and Kolam Makmur, Wanaraya village, Barito Kuala district, Province of South Kalimantan. The selected agro ecology is tidal land with a very acidic soil pH. This research is a descriptive analytical study in the form of field activities supported by laboratory analysis. The application of organic fertilizers and inorganic fertilizers for sweet potato cultivation in tidal land in South Kalimantan is intended to determine the differences of the change in soil microbial population, which is always dynamic toward its growth environment. The experimental design used was a randomized block with 7 treatments, namely: (1) application of Ponska fertilizer 300 kgs/ha, (2) application of ponska fertilizer 300 kgs/ha and organic fertilizer 3.0 t/ha, (3) application of organic fertilizer 3.0 t/ha, (4). fostered urea 150 kgs/ha, (5) application of SP36 fertilizer 100 kgs/ha, (6) fostered KCl 100 kgs/ha, and (7) without fertilization (control), with 3 times repetition, on a plot size: 6 m x 5 m and plant spacing: 25 cm.
Chemical analysis of the soil was conducted before and after planting of sweet potatoes. Chemical parameters analyzed were pH, C-org, N, P, K, Ca, and Mg. Selection of non-symbiotic nitrogen-fixing bacteria was conducted using streak plate and pour plate with NFB media. NFB medium composition was 0.4 g KH_2PO_4; 0.2 g $MgSO_4.7H_2O$; 0.1 g NaCl; 0.026 g $CaCl_2.2H_2O$; 0.017 g $FeCl_3.6H_2O$; 2 mg $Na_2MoO_4.2H_2O$; 3.58 g DL-malic acid; 0.025 g bromothymolblue; 1.75 g agar, 1 L of distilled water.

Selection of phosphate solubilizing microbial is done by using a selective medium Pikovskaya. The composition of medium Pikovskaya used were: 10.0 g of glucose, 5.0 g $Ca_3 (PO_4)_2$, 0.1 g $MgSO_4.7H_2O$, 0.2 g KCl, 0.01g $FeSO_4$, $MnSO_4$ 0.01g, 0.5 g $(NH_4)_2SO_2$, 0.5 g yeast extract , 1.0 L of distilled water and 2% agar (Rao, 1982).

The calculation of the amount of vesicular arbuscular mycorrhizae spores was preceded by filtering ground with *wet sieving and decanting method* (Gardemann, 1975). The percentage of root infection was observed with a microscope after clearing with KOH solution and staining with Trypanblue on the roots of plants observed. The level of root infection is determined by the formula (Phillips and Hayman, 1970):

$$\text{The infection rate} = \frac{\text{Number of infected root segments}}{\text{Total segment roots observed}} \times 100\%$$

RESULTS AND DISCUSSION

The study was conducted in two (2) locations, namely Sidomulyo and Kolam Makmur, Wanaraya village, Barito Kuala district, Province of South Kalimantan at the end of January 2016 to May 2016. The results of chemical analysis of soil from each site before planting sweet potatoes (Table 1) shows that the pH of the soil is very acidic, but the ability of soil to provide nutrients for plants is quite high.

Table 1. The results of chemical soil analysis before planting of sweet potatoes.

Parametre (unit)	Sidomulyo	Kolam Makmur
pH	3.66	3.68
C (%)	8.13	9.33
N (%)	0.41	0.48
P_2O_5 (ppm)	30.45	37.84
K (cmol/kg)	0.22	0.39
Na (cmol/kg)	0.42	0.55
KTK (cmol/kg)	140	127

pH of soil at both sites was very acidic at both locations, Sidomulyo with soil pH value of 3.66 and the Kolam Makmur village soil with a pH value of 3.68. Organic C content in both locations is high, respectively 8.13% at Sidomulyo and 9.33% at Kolam Makmur. The figure shows the soil composer material has not been properly degradated in both locations. N levels at both sites also did not differ much, 0.41% at Sidomulyo and 0.48% at Kolam Makmur, both are in average dignity level. Soil P dignity levels at both sites are high, while higher soil K levels is on Kolam Makmur site. CEC value of the soil at both locations is very high (> 40 cmol/kg), which shows the ability of soil to provide nutrients.

In such chemical status of soil (Table 1), the type of soil microbes that inhabit those locations are asidophile microbes, which are dominated by the bacteria and fungi (Table 2). Total population of soil microbes at both locations did not differ much, still within the range of 10^3 cfu/g of soil. In this range, the content of soil microbes' tidal land categorized as low.

Table 2. Type of soil microbes and the total population on the tidal area (cfu/g of soil).

Types of microbial	Location	
	Sidomulyo	Kolam Makmur
Fungi	$36,78 . 10^3$	$40,23 . 10^3$
Bacteria	$49.22 . 10^3$	$67,44 . 10^3$
Actinomicetes	$38,61 . 10^2$	$37,68 . 10^3$

Sweet potato varieties used are local varieties by named UBI which was obtained from the agricutural extension office. The application of organic and inorganic fertilizers carried out as planned in very small doses. The results of soil chemical analysis after 45 dap (Table 3 and Table 4). The results of this analysis after interaction between chemical properties of the soil, physical properties of soil after tillage and biological properties of the soil after planting sweet potatoes. The changes in soil microbial community structure by interaction of three factors, include application of fertilizer, processing the soil and the sweet potatoes growth.

Table 3. Results of soil chemical analysis at 45 dap in Sidomulyo, Wanaraya village

Treatment	pH	C (%)	N (%)	P_2O_5 (ppm)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)
P1	4.3	6.38	0.44	40.3	0.29	0.80	0.20
P2	4.3	5.80	0.32	67.8	0.38	0.76	0.21
P3	4.4	5.43	0.47	53.5	0.45	1.03	0.31
P4	4.4	5.49	0.38	59.5	0.41	0.93	0.23
P5	4.4	5.45	0.31	40.9	0.27	1.14	0.20
P6	4.3	5.05	0.51	42.5	0.38	1.54	0.27
P7	4.4	5.36	0.35	55.7	0.42	1.39	0.34

Information:

P1 = fostered ponska 300 kg/ha
P2 = fostered ponska 300 kg/ha of organic fertilizer and 3.0 t / ha
P3 = organically cultivated 3.0 t/ha
P4 = fostered urea 150 kg/ha
P5 = fostered SP36 100 kg/ha
P6 = fostered KCl 100 kg/ha
P7 = unfertilized

Compared with the initial conditions before planting sweet potatoes, the soil pH rise about 3.9 to 4.4 where the numbers initially only about 3.66-3.68. Soil's organic C value was being dropped off at the two sites, from 8.13% to 5.05-6.38% in Sidomulyo and from 9.33% to 3.91-7.23% in Kolam Makmur village. The degradation of soil organic C value in both sites indicates the biodegradation process of organic material carried by the initial microbes existed in that location. With the biodegradation of organic matter process, it is expected that the availability of soil nutrients is increased.

Table 4. Results of soil chemical analysis at 45 dap in the Kolam Makmur, Wanaraya village

Treatment.	pH	C (%)	N (%)	P_2O_5 (ppm)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)
P1	4.0	7.23	0.41	19.3	0.27	0.37	0.32
P2	4.0	6.42	0.37	42.3	0.40	0.41	0.59
P3	4.3	4.40	0.26	7.61	0.52	0.49	0.62
P4	3.9	6.38	0.37	5.11	0.29	0.45	0.50
P5	4.1	3.91	0.21	18.1	0.59	0.66	0.70
P6	4.0	5.78	0.50	40.3	0.34	0.46	0.33
P7	4.2	6.05	0.32	20.1	0.28	0.50	0.54

Information:

P1 = fostered ponska 300 kg/ha
P2 = fostered ponska 300 kg/ha of organic fertilizer and 3.0 t / ha
P3 = organically cultivated 3.0 t/ha
P4 = fostered urea 150 kg/ha
P5 = fostered SP36 100 kg/ha
P6 = fostered KCl 100 kg/ha
P7 = unfertilized

Organic farming management resulted in increased role of soil organisms, as indicated by the number of soil organism is more higher and the soil organism activities is better too. Replacement of chemical fertilizers to manure will stimulate food nets branching of soil biota such as bacteria, fungi, and also mycorrhizal (Prihastuti, 2016). Table 5 shows the total soil microbes in the soil sampling at the age of 45 HST plants. The total population of microbes calculated is a result of the interaction of physical, chemical, and biological aspects of the soil. Each location shows a specific character.

Different types of soil organisms play an important role in life processes that support the quality of the soil, such as the decomposition of organic matter and nutrient cycling, nitrogen fixation and aggregate formation and stabilization of soil ecosystems. With these natural events, it can be concluded that soil size is also determined by the amount of microbial biomass, respiration, potential mineralization of nitrogen (N), enzyme activity, the abundance of fungi, nematodes and earthworms, all of which have been used as an indicator of soil quality (Lee 1985; Doran, 1987; Dick *et al*, 1988; Kennedy and Papendick, 1995 ;. Wall and Moore, 1999).

Table 5. The results of calculation of the total soil microbial population (cfu/g of soil)
on the age of 45 dap sweet potato crop.

Treatment	Research Location	
	Sidomulyo	Kolam Makmur
P1	$35.8 . 10^6$	$33.6 . 10^6$
P2	$38.7 . 10^8$	$36.7 . 10^7$
P3	$36.3 . 10^7$	$35.4 . 10^7$
P4	$40.4 . 10^8$	$39.8 . 10^7$
P5	$38.2 . 10^6$	$37.7 . 10^6$
P6	$37.6 . 10^6$	$36.2 . 10^7$
P7	$35.4 . 10^5$	$42.1 . 10^4$

Information:

P1 = fostered ponska 300 kg/ha
P2 = fostered ponska 300 kg/ha of organic fertilizer and 3.0 t / ha
P3 = organically cultivated 3.0 t/ha
P4 = fostered urea 150 kg/ha
P5 = fostered SP36 100 kg/ha
P6 = fostered KCl 100 kg/ha

P7 = unfertilized

In seven trials conducted in the research, the total soil microbial population changes. This situation indicates a good interaction between the properties of the soil. Through the cultivation of land will provide a better environment growth for soil microbes, organic fertilizer is an instant nutrient that can also be used directly, the growth of sweet potato crops also provide a better environment for soil microbes. There are three main factors that contribute to the dynamics in the soil; the type of crop, soil type and management techniques (Loreau *et al*, 2001).

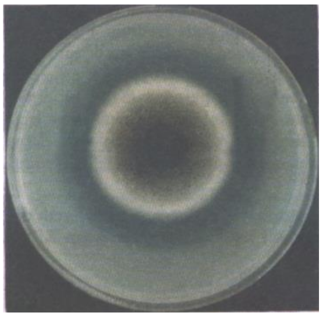
An increase in the total microbial population, which is one of the aspects of soil quality, the number > 10^6 cfu/g of soil indicates the class of a fertile soil. From the total population of soil microbes, inventory and identification need to be done in order to determine the types of initial microbes that exist in the tidal land. From several studies conducted by previous researchers, it is known that the beneficial microbes are beneficial to plants as nutrients or growth promoters' providers.

The results of planting origin soil microbial cultures of tidal land in selective agar media, it is known that there are types of beneficial microbes. Figure 1 shows the presence of free nitrogen-fixing bacteria (non-symbiotic), with an indication of the change of selective agar media NFB color from green to blue. The presence of non-symbiotic nitrogen-fixing bacteria allows the supply of nitrogen to the plants on it through the process of nitrogen fixation from the air.

Figure 1. Growth of non-symbiotic nitrogen-fixing bacteria
on NFB media by streak plate method.

By using selective Pikovskaya media, found of the types of non-symbiotic phosphate solubilizing microbes (either fungi or bacteria) that is characterized by the formation of a clear zone around the colony (Figure 2).

Figure 2. The growth of P solubilizing microbes on medium Pikovskaya
with a clear zone around it



Phosphate solubilizing microbes is known to excrete some form of chemical compounds such as formic acid, acetic, propionic, lactic, glycolic, fumaric and succinic (Schinner *et al.*, 1996). The mechanism of organic acids increase the availability of P soil such as through organic anions compete with orthophosphate on the surface of the positively charged colloid (Nagarajah *et al*, 1970; Lopez-Hernandez *et al.*, 1979); orthophosphate release of certain P metal bonding through the formation of metal-organic complexes (Earl *et al.*, 1979) and the modification of surface charge of colloids by organic ligands (Nagarajah *et al.*, 1970; Kwong and Huang, 1979).

Table 6. Average rate of mycorrhizal infection on the root system of sweet potato crops
and the number of spores were found in the area rizosphere

Location	Infection rate (%)	Number of Spores (spores/g of soil)
Sidomulyo	58.12	159.68
Kolam Makmur	53.76	196.25

Sweet potato crops are classified as plants responded to infection vesicular arbuscular mikrorizae. Prihastuti and Sudaryono (2006) states that the level of root infection that occurs is not determined by the number of spores present, but by the ability of mycorrhizal and plant roots response to the process of infection. Donahoe *et al*. (1983) states that the rate of infection by mycorrhizal roots is influenced by the sensitivity level of the host, climate and soil. Crops and soil pH affects the number of spores on rizosphere. Number of mycorrhizae spore in the tidal area of South Kalimantan reached 178 spores/g of soil, potential enough to infect plant roots to > 55%.

CONCLUSION

Tidal land is a marginal land categorized, that has a low microbial content (<10^3 cfu / g of soil), but with a quite high diversity. There are several types of beneficial microbe origin tidal land South Kalimantan, covering non-symbiotic nitrogen-fixing bacteria, phosphate solubilizing bacteria and fungi and vesicular-arbuscular mycorrhizae.

By the application of organic fertilizers and/or an organic fertilizer on sweet potato crop in tidal land making a total increase of soil microbial populations in tidal land. This situation gives hope to increase the productivity of biologically tidal area by utilizing the soil microbial activity contained therein. The success of this research will be to realize the sustainable agriculture program, to assess the biological aspects of tidal land, and combine them with the physical and chemical aspects that has been done previously

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