Potential of Reducing Sulphate Bacteria on Increasing soil pH and Decreasing Sulphate Levels on Acid Sulphate Soil

Mazlina, Asmarlaili S. Hanafiah, A. Rauf, Edy Sigit Sutarta

Abstract: Acid sulphate soils have low pH, low nutrients availability and soluble aluminium and iron are high. They have a pyrite when oxidized will cause a decrease of pH until <3.5. We need a technology that acid sulphate soils can be used for agricultural development. The purpose of this research to examine the potential of sulphate reducing bacteria (SRB) to the chemical properties of acid sulfate soil. The experiment used a factorial randomized block design was conducted in laboratory. The first factor was the condition of acid sulphate soil, 100% and 110% of field capacity. The second factor was the best isolates from preliminary research. Parameters were soil pH and chemical properties of acid sulphate soil after incubating for 1 and 2 weeks. The results showed that soil condition (110% of field capacity) could increased soil pH significantly. The best isolates of SRB in the first week of soil pH is isolate LK3 from paper mill waste. This isolate increase soil pH in 100% or 110% of field capacity. Observation of acid sulphate soil content showed that SRB could decrease sulphate content in soil in both conditions.

Keywords: Acid Sulphate Soils, Sulphate Reducing Bacteria

1 INTRODUCTION

Acid sulphate soils (ASS) are naturally occurring soils, containing sulphide minerals such as pyrite (FeS2) up to 15 wt %, and are commonly found along thecoastline (approximately 6,71 million ha) which distributed in Kalimantan, Papua and Sumatra [2]. Acid sulphate Soils are generally under-consolidated materials and construction of infrastructure in. Acid sulphate soils are often challenging due to the oxidation of pyrite from the disturbance caused by construction. Agronomic constraints faced in acid sulphate soils are direct effects of acidity mainly due to increasing solubililty (posioning) of Al and Fe (III), Mn and H ions, phosphate deficiency due to fixed by Fe and Al to form Fe-P and Al-P, low base saturation, nutrient deficiency and salinity. In flooded condition, such soils also poisoned by iron (II), H_2S, CO_2, and organic acids. Whereas soil physical constraints are root development at sulfate horizon due to water deficiency[1]. In flooded conditions, pyrite compounds are stable but in aerobic conditions pyrite will be oxidized to form sulfuric acid which results high levels of acidity and solubility of Al in the soil and poor nutrients. Such soils are potential for focrops and annual crops. Some of the land has been cleared for transmigration and planted with rice, pulses and fruits but generally the yield are below crop production potential [3].. Application of ameliorant and fertilizer are important factors to improve the productivity of acid sulphate soils. Some research found that application of organic matter accompanied by N, P, K fertilizer in accordance with soil nutrient status and plant needs can increase crop production in swamps acid sulfate soil [4]. Farming in acid sulphate soils requires new technology to achieve good production, maintain the environment degradation.

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Some bacteria were able to use sulfate as electron receptors in their respiration and such bacteria are known as sulphate reducing bacteria (SRB). The reaction of sulphate reduction with sulphate reducing pH due to the use of H^+ ions in reduction reaction [1][5]. In acid sulphate soils that have been oxidized and re-flooded, reductions rate by sulphate reducing bacteria runs slowly due to low organic matter content which inhibits the growth of an aerobic bacteria properly[6], showed that sulphate reducing bacteria application reduce the content of ex-coal mining soil and increased the growth of rubber plants in polybags after one month of suphate reducing bacteria isolate treatment. [7] showed that sulphate reducing bacteria were able to grow on very acidic media (3.5) and could increase pH from 3.9 to 5.42 and reduce soil sulfate levels from 319.44 ppm to 235.10 ppm or 26, 40% and increase production by 32.56%. The use of sulphate reducing bacteria as a microbial fertilizer is still not developed yet. Further research is needed on the use of sulphate reducing bacteria as biological in addition to the provision of ameliorant and chemical fertilizers to increase the productivity of acid sulphate land. Due to the reason this study was conducted to study the effect of incubation of sulphate reducing bacteria in compost medium on the chemicalon properties of acid sulphate soil was taken from PT. Mopoli Raya Kuala Simpang Aceh Tamiang. Sulphate reducing bacteria was passed two tests, namely qualitative tests, Both of tests are useful for selecting isolates that will be used in potential tests. Sulfate reducing bacteria isolates from each selected source will be isolated in the isolation stage. Sulfate reducing bacteria isolates from each selected source will be isolated in the isolation stage.

1.1. Isolation and Purification of Sulfate Reducing Bacteria

Sulphate Reducing Bacteria that have been tested is grown in a posgate solid medium. Sulphate reducing bacteria which grows in a tube is scrabe in the surface onto the surface face to the surface by inserting ose needle into test tube and scratched onto the surface of media with a zig zag technique. Petridish was closed and incubated in an anaerobic jar containing anaerobe kit for 5-6 days in the incubator. The growing colonies then purified by transferred to the reaction tube containing solid Posgate media according to each isolate and labeled. Successfully purified colonies are ready to be proceeding for potential test stage [7][8][9].

1.2. Potential Test of Sulfate Reducing Bacteria in Acid Sulfate Soil at Laboratory Scale

This research used a factorial randomized block design with 3 replications.. The best of sulphate-reducing bacteria were cultured as much as 10% in sterile straw compost (v/v) and incubated for 4 days. After the bacteria grow (indicated by bubbles formation on the compost surface), immediately put into acid sulfate soil placed in a plastic jar. The soil is watering at 100% and 110% of fielld capacity. For treatment, the control was carried out the same as other treatment the field capacity. For treatment, the control was carried out the same as other treatments, but not given superior sulphate-reducing bacteria. Tests were carried out for 20 days of incubation [10][11].

2. RESULTS AND DISCUSSION

2.1. Soil pH

The pH measurements results of acid sulphate soils which have been inoculated by sulphate reducing bacteria and incubated for 1 and 2 weeks on changes in soil pH are listed in Table 1 Table 1 showed that there were an increase in soil pH in several treatments of sulfate reducing bacteria isolates both in the first and second weeks after treatment. In the first week, there was an increase in pH around 9.67% from 4.86 to 5.33 and in the second-week pH increased to 5.37 or 10.49%. Increasing soil pH mainly occurs in 110% of field capacity which is 5.06 to 5.33 in the first week and 5.06 to 5.37 in the second week. In dry conditions, only a few isolates showed an increase in pH namely isolate AP3 and AP4 from Sidebuk-debuk sulfuric water in pH.

Table 1. *Changes in soil pH with SRB Application on Sulphate Acid Soils*

Isolate	Soil pH in First Week		Soil pH in Second Week	
	Soil condition		Soil condition	
	K_0 (100% FC)	K_1(110% FC)	K_0(100% FC)	K_1(110% FC)
Kontrol	4,86	5,11	5,07	4,98
AP1	4,75	4,97	5,06	5,07
AP3	4,99	5,19	5,14	5,13
AP4	4,86	5,14	5,12	5,14
AP6	4,66	4,95	4,76	5,27
AP7	4,55	5,2	4,76	5,14
AP8	4,55	5,05	4,59	5,37
AP9	4,8	4,99	4,74	5,02
AP10	4,94	5,12	4,94	5,01
TSM1	4,81	4,98	4,74	5,1
TSM2	4,46	5,1	4.83	5,23
TSM3	4,61	5,13	4.79	4,81
TSM4	4,45	5,27	4.74	5,08
TSM5	4,92	5,03	4.82	4,69
TSM6	4,56	4,92	4.42	4,79
LK1	4,64	5,23	4,51	4,77
LK2	5,06	4,88	4,9	5,05
LK3	4,86	5,33	4,51	5,02
LK4	4,6	5,22	4,92	4,96
LK5	4,79	5,19	4,77	4,64
LK6	4,66	5,29	4,38	5,04
	4,73a	5,11b	4,78a	5,01b

Note: Number is followed by the same letter showed not significantly different at α 5% according to the Duncan Multiple Range Test

The best isolates in increasing pH in dry conditions was LK2, AP3, AP10 and TSM6, respectively and in field capacity was LK3, TSM4, LK6, LK3 and LK4. In the second week at dry conditions, only AP3 and AP4 were able to raise pH while in 110% of field capacity, SRB derived from Sidebuk-debuk sulfur hot water out performed the increase in soil pH, namely AP8, AP6, TSM2, AP7 and TSM1.

2.2. Soil Sulfate Level

The results of changes in sulfate content measurements in acid sulfate soils which have been inoculated by sulfate-reducing bacteria and incubated for 1 week and 2 weeks are listed in Table 2.

Table 2. *Changes in Soil Sulfate Content with SRB Application*

Isolate	Soil sulfate Content in the First Week		Soil sulfate Content in the Second Week		
	K0(100% FC)	K1(110 % FC)	K0(100% FC)	K1(110% FC)	
	---------- ppm ----------		---------- ppm ----------		
Kontrol	103,10	72,85	95,05	82,89	bc
AP1	201,25	72,75	179,06	55,02	ab
AP3	130,00	209,25	107,77	158,50	a
AP4	110,50	83,50	84,54	46,42	c
AP6	165,00	163,25	82,66	76,45	bc
AP7	95,50	97,50	83,40	71,67	bc
AP8	75,50	50,75	76,41	42,74	c
AP9	76,00	89,00	68,27	52,67	c
AP10	92,50	79,25	78,84	70,94	bc
TSM1	98,00	75,50	83,80	61,93	bc
TSM2	129,75	54,25	123,27	45,00	bc
TSM3	88,75	126,00	76,51	77,44	bc
TSM4	76,75	61,50	66,49	38,76	c
TSM5	105,75	114,50	90,56	93,77	abc
TSM6	119,25	71,75	110,65	67,54	abc
LK1	125,75	90,00	116,66	78,39	bc
LK2	104,50	65,00	87,38	59,17	bc

LK3	*72,75*	*50,50*	*67,71*	*40,72*	*c*
LK4	*141,25*	*107,75*	*111,21*	*65,70*	*abc*
LK5	*64,75*	*79,25*	*49,50*	*65,75*	*c*
LK6	*82,00*	*73,75*	*64,72*	*49,02*	*c*
Average	*107,55*	*89,90*	*90,69 a*	*65,26*	*b*

Note: the number is followed by the same letter show not significantly different at α 5% according to the Duncan Multiple Range Test

The Observations in the firts week had shown that application of sulphate reducing bacteria could reduce soil sulphate levels . The lowest sulphate content was found in LK3 treatment as much as 61,63 ppm while AP3 had higher soil sulphate content as much as 69,63 ppm. Watering up to 110% of field capacity could reduced soil sulphate content. Interaction of LK3K1 had lowest sulphate content in the soil namely 50,.50 ppm while AP1K0 has the highest sulfate content, namely 201.25 ppm.. In the second week, the application of sulfate-reducing-bacteria had shown that SRB isolates could significantly reduce sulphate levels in the soil. The lowest sulfate levels found in TSM4 as much as 52.62 p ppm but not significantly different from the control, AP4, AP6, AP7, AP8, AP9, AP 10, TSM1, TSM2, TSM3, TSM6,, TSM 7, LK1, LK2, ,LK3, LK4, LK% and LK6. Watering up to 110% of field capacity can significantly reduce sulfate in the soil. Interaction of LK_3K_1 treatment has the lowest sulfate content in the soil, namely 40.72 ppm.

3. DISCUSSIONS

Sulphate reducing bacteria is able to increase the pH of acid sulphate soils with an average pH fall in slightly acidic category. Isolates application can reduce sulfate levels. The increase in pH by sulphate reducing bacteria application is influenced by reduction of sulfate which contributes OH^- thus increasing the soil pH. [12][13][14]was states that in sulfate reduction reaction, the more the sulfate is reduced, the more OH^- ions are released so the pH will increase. The decrease in sulphate content is influenced by the ability of superior sulphate reducing bacteria isolates in reducing sulphate. Ability of each isolate from the same or different sources is differ reducing sulphate in the soil. Sulphate reducing bacteria will reduce sulphate by using it as an electron acceptor [15][16]was states that in sulphate reduction, sulphate reducing bacteria uses sulphte as an electron acceptor and uses organic material as a carbon source. Watering treatment up to 110% of field capacity showed better increase in pH than 100%. This is because 110% of field capacity creating a reduction environment. Under reduced conditions, acid sulfate soils will be more stable. This is consistent with [17][18] which states that water saturation would make sulfate in stable condition and reducedRegulating of soil water content in acid sulphate soils also affects sulfate levels in the soil. Increasing soil water content up to 110% of field capacity will reduce Sulphate content. [19][20] states that one of sulphate reducing bacteria life requirements is anaerobic conditions and [21][22] confirmed that acid sulfate soils will be more stable at reductive conditions that can be achieved by regulating water condition in the soil.

4. CONCLUSIONS

Application of Sulfate reducig bacteria isolates serve to improve soil pH and reducing sulphate content levels in the acid sulphate soil. Water content of up to 110% of field capacity will create conditions for SRB's living space and create a stable sulfur state in the soilWatering treatment up to 110% of field capacity

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