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SELECTION OF TIDAL LOCAL VARIETY RICE AND COMPOST UTILIZATION IN RICE FIELD CONTAMINATED WITH ACID MINE DRAINAGE

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ABSTRACT

The objectives of the research were to find out the response differences of local variety rice crops and the soil chemical properties added with compost in the fields contaminated with acid mine drainage, and to produce the cultivars of local rice which are tolerant and adaptive, with the proper provision of compost showing the best result. The result of the research indicated that: (1) the contamination of acid mine drainage reduced the soil pH by 27.4 %, increased the dissolved Fe by 51.6 %, and reduced the available P by 30.1 %. The provision of compost until 15 t ha^{-1} did not affect pH and element N in the soil. The increase in pH was only 5.86 % compared to pH in the field without compost. The higher the dose of compost was added, the more the content of organic C, P and K would increase, and conversely the more the dissolved Fe would decrease; (2) the provision of compost did not affect the characters of the crop height, the tiller number, and the tassel number, except the empty grain. The higher the dose of compost was added, the number of empty grains tended to decline. The growth of crop height, tiller number and tassel number of the local rice varieties were higher than those of superior variety Ciherang (control); (3) the interaction of compost with rice varieties showed the effect on the grain number, the 1000 seed weight, and the grain yield (t ha^{-1}). The provision of compost with the dose of 15 t ha^{-1} to Siam Unus variety could increase the grain number, the grain content and the grain yield (4.72 t ha^{-1}), followed by Siam Runut. The higher the dose of compost was added, the more the tassel number, the grain number, the grain content and the grain yield would increase.

Keywords: Rice crops, acid mine drainage, soil chemical properties

INTRODUCTION

The negative impact resulted from the mining activities was liquid coal waste. The mining waste in the form of coal mine wastewater from the washing process, namely *Acid Mine Drainage* or *Acid Rock Drainage* flows out of the mining area and contaminates the river and the run-off which flow to the fields around the mines.

Acid mine drainage is the liquid formed due to the oxidation of sulfide minerals, especially pyrite (FeS_2) that results in acid sulfate. This process affects pH and heavy metals in soil, the water surface and rivers (Horan, 1999; Sexstone *et al*., 1999; Skousen *et al*., 1999). The contamination of acid mine drainage causes the dissolution of other minerals and releases cations, such as Fe, Mn, Al, Cu, Zn, Cd, Ni, and Hg (Widdowson, 1990). The decline in soil pH (very acid) causes the availibilty and the balance of nutrient impaired and not available, and the solubility of heavy metals (Fe, Al, dan Mn) causes the crops can not grow well in fields located around the coal mining.

The local farmers reported that before the coal mining opened, the paddy productivity ranged from 3.5 t ha^{-1} to 4.0 t ha^{-1}, but after the mining activities, there was the decline in the grain

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productivity ranging from 0.50 t ha^{-1} – 0.85 t ha^{-1} which kept decresing that eventually the land itself was not productive and could not be planted.

One of the ways to solve this problem was to utilize the organic matter of compost and the rice cultivation of local cultivars adaptable to the acidic soil. Compost is a rich source of active soil organism, organic matter, and nutrients that increase the soil resistance. The provision of compost as the organic matter through the decomposition process will result in many organic acids containing derivatives of phenol acid and carboxylic acid (Tan, 1982; and Stevenson, 1982). The phenol acid and carboxylic acid have functional groups containing oxygen that is the reactive footprint in binding metals, including Al and Fe. Thus, the activity of Al and Fe ions that are toxic for the crops could be reduced.

The use of local cultivars which are tolerant and adaptive is one of the ways to solve problems of land contaminated with acid mine drainage. Local crop species can ecologically adapt to the local environmental conditions.

The objective of the research were to find out the response differences of local variety rice crops and the chemical properties of soil, which was added with compost, in the fields contaminated with acid mine drainage, and to produce cultivars of local rice which are tolerant and adaptive, with the dose of compost resulting the best.

MATERIALS AND METHODS

The resaerch was conducted in February 2011 – September 2012 in the mining area of PT Binuang Bara Muda (BBM) in Sabah village, Tapin Selatan sub-district, Tapin regency, South Kalimantan province. The experiment materials were compost, tillers, husk ash, Urea fertilizer, SP-36, insecticide Dursban 20 EC and fungicide Ridomil 35 SD. The rice tillers of local cultivars were Siam Damai, Siam Sabalas, Siam Unus, and Siam Runut. Ciherang variety was used as the control.

The method was split plot design with the environmental design of Random Group Design three repetitions. The first factor was the dose of compost consisting of 4 levels: without compost (0 t ha^{-1}) as the control, 5 t ha^{-1}, 10 t ha^{-1}, and 15 t ha^{-1} which were placed in the main plot, while the local culivars were placed in sub-plot.

RESULTS AND DISCUSSION

Soil Chemical Properties

Table 1. Average effect of compost on pH, Organic C, Fe^{+2}, N (%), P, and K in soil contaminated with acid mine drainage

Compost (C) (t ha^{-1})	*pH (H_2O)*	*Organic C (%)*	*Dissolved Fe (ppm)*	*N (%)*	*P (ppm)*	*K (mg/100 g)*
Co = 0	3.87	2.013 a	115.08 b	0.105	2.129 a	4.430 a
C1 = 5	3.90	2.080 ab	106.32 b	0.105	2.809 a	4.701 a
C2 = 10	3.92	2.205 b	95.26 ab	0.098	3.366 a	5.107 a
C3 = 15	4.09	2.555 c	83.48 a	0.107	6.549 b	5.943 b
Average	3.94	2.213	100.04	0.104	3.713	5.045

Explaination: The average effect having the same superscript mark in each column indicates no significant difference based on Duncan's Multiple Range Test at level $\alpha = 0.05$

The interaction of compost with the variety and the single factor effect of variety each had no significant effect (P > 0.05) on the soil chemical properties: pH, Organic C, dissolved Fe, N, P and K. Meanwhile, the independent effect of compost showed significant difference, except for pH and element N. The average effect of compost on pH content, Organic C, Fe^{+2}, N (%), P, and K in the soil contaminated with acid mine drainage is presented in Table 1.

The contamination of acid mine drainage would reduce soil pH from 4.93 to 3.87 (decrease by 27.4 %), increase dissolved Fe from 75.91 ppm to 115.08 ppm (increase by 51.6 %), increase Organic C from 1.35 % to 2.013 % (increase by 49.1 %), and reduce the available P from 2.77 ppm to 2.013 ppm (decrease by 30.1 %), while the changes in N and K were relatively very small.

Not influential compost on the soil pH was resulted from an exposed pyrite in the field area experiencing oxidation. According to Dent (1986) in the process of oxidation, pyrite releases the sulfate acids causing the soil pH decrease to < 4. The result of the research indicated that the provision of compost with the dose of 15 t ha^{-1} did not increase the soil pH; the average pH was 4.09. The provision of compost at 15 t ha^{-1} could only increase the soil pH by 5.86 % compared to without compost. This result was in line with Margaretta's research (2010) reporting that the provision of bio-fertilizer Mikoriza to the ex-coal mine land did not significantly affect the soil pH.

The content of soil organic C increased after the provision of compost. The provision of compost would increase the soil organic C compared to without compost. The content of available P and K resulted from the provision of compost showed that there was the difference in the provision of compost at 15 t ha^{-1}. The higher the dose of compost was added, the content of organic C, available P and K would increase, and conversely the dissolved Fe would decrease. It indicated that the provision of organic compost affected organic C, P-Bray, and K, and dissolved Fe. According to Hakim *et al*. (1986), carbon is the biggest element in organic matter, about 44 %, so the provision of organic matter in the soil could increase carbon in soil. The carbon in soil would improve the soil properties to be better physically, chemically, and biologically.

According to Setijono (1996) the result of organic matter decomposition in improving the soil fertile results in organic acids of the ionization of organic acids producing new negative charge with the capability to chelate various metal elements, such as aluminium (Al), iron (Fe), zinc (Zn), cuprum (Cu), cobalt (Co), lead (Pb), and mercury (Hg). The process of metal chelation can reduce the toxicity of the elements and the fixation capacity of phosphate (P) by Al, and increase the avaibility of P in soil due to the decline in absorptive capacity of Al toward phosphate anion and the soil KTK. According to Stevenson (1994) about 20 % - 70 % of the exchange capacity generally sourced on colloidal humus, so there is a correlation between KTK and organic matter

The Growth and Grain Yield

The interaction between compost and variety (K x V) and the single factor of compost each had no significant effect (P > 0.05) on the growth of the crop height and the tiller number of the local rice variety, while the effect of the variety single factor showed the significant difference (P < 0.01). The growth of the crop height of local rice variety cultivated in the fields contaminated with acid mine drainage was higher than Ciherang variety as the control, while among local varieties, the crop height growth of Siam Sabalas higher than Siam Damai, Siam Unus and Siam Runut. The tillers of local variety were more in number than Ciherang variety (the control), while the number of tillers among the local varieties was not significantly different (Table 2). It indicated that the growth of local variety was better than

the superior variety in the land contaminated with acid drainage. The inhabitation of the growth of Ciherang variety caused by the the contamination of land with acid mine drainage resulted in toxicity of Fe on its growth.

Table 2. Average growth of crop height, tiller number, and crop number of local rice variety

Variety (V)	*Crop Height (cm)*	*Tiller Number (stem)*	*Tassel Number (tassel)*
V1 = Ciherang (Control)	53.90 a	5.03 a	4.00 a
V2 = Siam Damai	88.12 b	17.32 b	8.83 d
V3 = Siam Sabalas	99.15 c	16.87 b	5.92 b
V4 = Siam Unus	90.07 b	18.65 b	7.83 c
V5 = Siam Runut	85.63 b	17.57 b	7.75 c

Explaination: The average growth having the same superscript indicated that there was no significant difference based on DMRT at level $\alpha = 0,05$

The research results reported by the researchers showed that the content of Fe in soil solution leading to Fe toxicity in rice crops is very variable. According to Tadano and Yoshida (1978) the concentration of Fe 100 ppm with pH 3.7 and Fe 300 ppm with pH 5.0 can be a toxic to the crops. The concentration of iron (Fe^{+2}) in soil without the provision of compost showed that the content of dissolved Fe^{+2} was 115.08 ppm with pH 3.87. It indicated that the condition of land without the provision of organic compost was in the criteria that it could toxify the crops. This research result is consistent with the report of Fageria *et al*. (2008) reporting that the symptoms of toxicity in crops are indicated by the decline in the crop height, the decrease in tiller number, and the decrease in the crop chlorophyll. The crops toxified with Fe have fewer roots which are coarse, short and dark brown (Sahrawat, 2004; Fageria *et al*., 2008).

The single factor of compost and the interaction between compost and rice variety each had no significant effect ($P > 0.05$) on the tassel number of rice crops contaminated with acid mine dranaige, while the factor of variety showed the very significant effect on the tassel number. The tassel number in local varieties cultivated in field areas contaminated with acid mine drainage was more than the tassel number in the superior variety Ciherang as the control. The highest number of tassels was in the Siam Damai variety, followed by Siam Unus Batola, Siam Runut and Siam Sabalas (Table 2).

The grain number of rice crops contaminated with the acid mine drainage was very significant ($P < 0.01$) affected by the interaction of compost with local variety, the single factor of compost and the local variety. The average effect of the interaction of compost with local variety is presented in Table 3.

The provision of compost from 5 t ha^{-1} until 15 t ha^{-1} to the Ciherang variety was not different from the control treatment (without compost), while to Siam Damai variety the difference was identified in the provision of compost with the dose of 15 t ha, and the grain number was more than with the dose of 10 t ha^{-1}, 5 t ha^{-1}, and without compost. Siam Sabalas, Siam Unus, and Siam Runut with the provision of compost indicated the higher number of grains compared to without compost. In the provision of compost at 15 t ha^{-1} to Siam Unus variety, the grain number was higher than the other local varieties at various doses of compost. The higher the dose of compost was added, the more the grain number in each variety would

increase. This indicated that the higher the dose of compost was added, the more the grain number would increase.

Table 3. Average effect of the interaction of compost with variety on the grain number of rice crops contaminated with acid mine drainage

Compost(C)	*Variety*	*Grain number/tassel (seed)*	*1000 Seed Weight (g)*	*Dry milled grain yield (t ha-1)*
C0	V1 = Ciherang	71.30 a	11.28 a	0.90 a
C0	V2 = Siam Damai	82.70 abc	15.67 bcd	2.15 bcdef
C0	V3 = S. Sabalas	80.30 ab	14.67 b	1.58 b
C0	V4 = Siam Unus	88.00 abcd	18.84 fg	1.87 bcde
Co	V 5= Siam Runut	105.70 bcdef	16.32 cde	1.85 bcde
C1	V1 = Ciherang	86.30 abcd	20.42 h	1.65 bc
C1	V2 = Siam Damai	89.30 abcde	16.17 cd	2.35 def
C1	V3 = S. Sabalas	102.00 bcdef	15.33 bc	1.77 bcd
C1	V4 = Siam Unus	106.30 cdef	19.25 g	2.30 def
C1	V 5= Siam Runut	124.70 f	16.74 cde	2.43 ef
C2	V1 = Ciherang	87.70 abcd	25.76 i	1.78 bcd
C2	V2 = Siam Damai	97.00 abcde	16.81 de	2.51 fgh
C2	V3 = S. Sabalas	114.00 ef	16.01 bcd	2.06 bcdef
C2	V4 = Siam Unus	122.70 f	19.34 gh	3.03 ghi
C2	V 5= Siam Runut	152.00 g	16.99 de	3.29 i
C3	V1 = Ciherang	97.70 abcde	26.57 i	2.23 cdef
C3	V2 = Siam Damai	108.30 def	16.87 de	3.09 hi
C3	V3 = S. Sabalas	123.00 f	16.65 cde	2.60 fgh
C3	V4 = Siam Unus	242.70 h	19.90 gh	4.72 k
C3	V 5= Siam Runut	173.00 g	17.64 ef	4.01 j

Explaination: The average effect having the same superscript mark at each column indicated that there was no significant difference based on DMRT at level $\alpha = 0.05$

The effect of single factor of compost and variety each indicated significant difference ($P < 0.01$) on empty grains, while the effect of the interaction of compost with variety was not significant. The average single effect of compost and variety on the percentage of empty grain is presented in Table 4. The empty grain percentage in the provision of compost at 15 t ha^{-1} smaller than the empty grain percentage in the provision of compost at 10 t ha^{-1}, 5 t ha^{-1} and without compost. The percentage of empty grains in Siam Damai variety was not different from the percentage in Siam Sabalas, and smaller compared to Ciherang, Siam Unus and Siam Runut. The condition of land contaminated with acid mine drainage with pH < 4 and slightly high dissolved Fe^{+2} caused the impaired balance, so the N, P, and K nutrients were not available. The aciditic land due to the acid mine drainage contamination affected the empty grains.

The compost provision, the variety and their interaction each had very significant effect (P< 0,01) on the 1000 seed weight and the dry milled grain yield of the rice crops contaminated with acid mine drainage. The local variety without compost had the 1000 seed weight heavier

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than Ciherang variety without compost. When Ciherang variety was added with compost at 5 t ha^{-1}, it was not significantly different from Siam Unus variety added with compost at 10 t ha^{-1} and 15 t ha^{-1}, and its 1000 seed weight heavier than other local varieties which were added with various doses of compost. Ciherang variety added with compost at 10 t ha^{-1} was not different from added with 15 t ha^{-1}, and its 1000 seed weight was heavier than the local varieties at various doses of compost (Table 3).

Table 4. Single effect of compost and variety on empty grain (%) of local variety of rice crop contaminated with acid mine drainage

No.	*Compost (C)(t ha^{-1})*	*Empty grain (%)*	
		Data of Transf.Arc. Sin$\sqrt{X}$	*Original data*
1	Co = 0	33.85 b	30.98
2	C1 = 5	30.37 b	28.52
3	C2 = 10	30.26 b	21.40
4	C3 = 15	24.46 a	18.92
	Variety		
1	V1 = Ciherang (Control)	32.47 b	29.14
2	V2 = Siam Damai	25.99 a	19.48
3	V3 = Siam Sabalas	27.24 a	21.26
4	V4 = Siam Unus Batola	30.39 b	26.51
5	V5 = Siam Runut	32.07 b	28.39

Explaination: The average effect having the same superscript mark indicated that there was no significant difference based on Duncan's Multiple Range Test at level $\alpha = 0.05$

The grain yield of local variety without compost was higher than Ciherang variety without compost. In the provision of compost at 5 t ha^{-1}, the dry milled grain yield of Ciherang variety was higher than without compost, while in local varieties the difference of grains was significant at the compost provision at 10 t ha^{-1}. In the compost provision at 15 t ha^{-1}, Siam Unus variety showed the higher grain yield compared to other varieties at various doses of compost. It indicated that the provision of compost could reduce the concentration of dissolved Fe, so the compost provision at 15 t ha^{-1} could increase the grain yield. The higher the dose of compost was added, the more the grain yield would increase (Figure 1). According to Audebert (2006) iron fero absorbed by the crops and concentrated in the leaves results in the change of leave color, decreases tiller number and reduces the yield. The decline in the yield due to toxicity was also caused by the disturbance of metabolism process in crops leading to the change in agronomic and physiological properties of the crops.

The greater response to the increase in compost provision was identified in Siam Unus followed by Siam Runut, Siam Damai, Siam Sabalas, and Ciherang. This result indicated that the level of iron toxicity and grains were affected by the environmental condition and depended on the sensivity and tolerance of the variety. The research result indicated that with the provision of compost at 15 t ha^{-1}, Siam Unus and Siam Runut showed a good response to the land contaminated with acid mine drainage, while Ciherang variety seemed to be sensitive compared to other local varieties. The result of the research from Sahrawat (2000) Audebert and Sahrawat (2000) showed that the high yield of rice physiologically corresponds to its tolerance to the iron toxicity.

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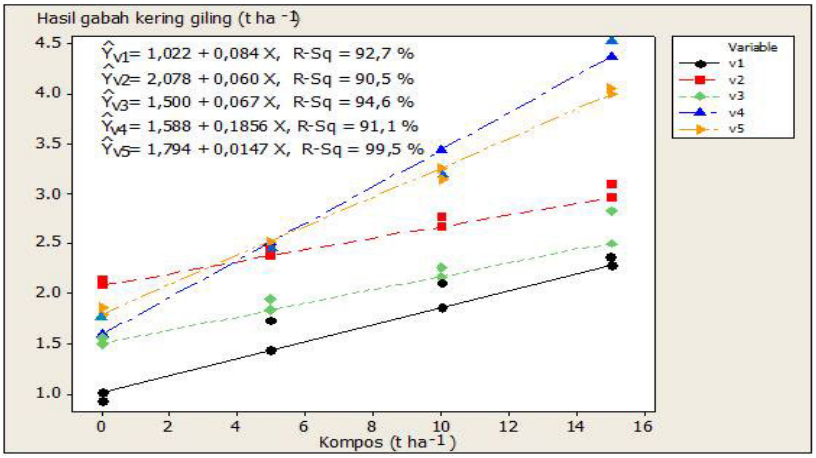

Figure 1. Effect of compost on dry milled grain yield of local rice variety crops

CONCLUSION AND SUGGESTIONS

1. The contamination of acid mine drainage reduced soil pH by 27.4 % (pH from 4.93 to 3.87), increased the dissolved Fe by 51.6 % (from 75.91 ppm to 115.08 ppm), and reduced the available P by 30.1 % (from 2.77 ppm to 2.013 ppm). The provision of compost at 15 t ha^{-1} did not affect pH and element N in soil. The increase of soil pH was 5.86 % compared to soil pH without compost. The higher the dose of compost was added, the more the content of Organic C, P and K would increase, and conversely the more the dissolved Fe would decrease.
2. The provision of compost did not affect the characters of the crop height, the tiller number, and the tassel number except the empty grain. The higher the dose of compost was added, the more the empty grains would decrease. The growth of crop height, the tiller number, and the tassel number of local variety was higher than the superior variety Ciherang (control).
3. The interaction of compost with variety indicated the effects on the grain number, the 1000 seed weight, and the grain yield (t ha^{-1}). The provision of compost at 15 t ha^{-1} to Siam Unus variety could increase the grain number (247.7 seeds), the filled grains, (198.67 seeds) and the grain yield (4.72 t ha^{-1}), followed by Siam Runut. The higher the dose of compost was added, the more the tassel number, the grain number, the filled grain and the grain yield would increase.

SUGGESTIONS

1. The provision of compost with the dose of 15 t ha^{-1} can be used to increase the productivity of rice crops in the land contaminated with acid mine drainage.
2. It is necessary to conduct further study on the superior varieties tolerant in acidic soil, to be experimented in the land contaminated with acid mine drainage.

REFERENCES

Audebert, A. & Sahrawat, K. L. (2000). Mechanisms for Iron Toxicity Tolerance in Lowland Rice. *J. Plant Nutr., 23*, 1877- 1885.

Dent, D. (1986). *Acid Sulphate Soils: A Baseline for Research and Development.* ILRI Publ. 39. The Netherlands.

Fageria, N. K., Santos, A. B., Filho, M. P. B. & Guimaraes, C. M. (2008). Iron Toxicity in lowland rice. *J. Plant Nutr., 31*, 1676 – 1697.

Hakim, N., Nyakpa, M. Y., Lubis, A. M. Nugroho, S. G., Rudi Saul, M., Amin Diha, Go Ban Hong, M. & Bailey,H. H. (1986). *Dasar-Dasar Ilmu Tanah*. Universitas Lampung.

Horan, J. (1999). *Acid mine Drainage Experiment.* Dept. Of Chemistry and Geochemistry, Colorado School of Minea, Golden, CO. USA.

Margarettha. (2010). Pemanfaatan Tanah Bekas Tambang Batubara dengan Pupuk Hayati Mikoriza sebagai Media Tanaman Jagung Manis. *J.Hidrolitan, 1*(3), 1-10.

Sahrawat, K. L. (2000). Elemental Composition of the Rice Plant as Affected by Iron Toxicity Under Field Conditions. *Comm. Soil Sci. Plant Anal., 31*, 2819 – 2827

_____. (2004). Iron Toxicity in Wetland Rice and the Role of Others Nutrients. *J. Plant Nutr., 27*, 1471 – 1504.

Setijono, S. (1996). Intisari *Kesuburan Tanah*. Penerbit IKIP Malang. Hal. 62-66.

Sexstone, J., Kousen, J. G., Calabrese, J., Bhumbla, D. K., Cliff, J., Sencindiver, J. C. & Bissonnette, G. K. (1999). Iron Removal from Acid Mine Drainage by Wetland. *In Proceeding of American Society for Surface Mining and Reclamat*ion (*ASSMR) 16th Annual Meeting in Conjunction with Wester Region Ash Group 2nd*. Annual Forum: Mining and Reclamtion for the Millennium, Scottsdale, Arizona, August 13-19. Vol.2: 621-620.

Skousen, J. G., Cliff, J., Sterner, P., Calabrase, J. & Ziemkiewicz, P. (1999). Acid Mine Drainage Treatment with A Combined Wetland/Anoxic Limestone Drain: Greenhouse and Field System. *In Proceeding of American Society for Surface Mining and Reclamation (ASSMR) 16th Annual Meeting in Conjunction with Wester Region Ash Group 2nd*. Annual Forum: Mining and Reclamtion for the Millennium, Scottsdale, Arizona, August 13-19. Vol.2: 621-620.

Tan, K. H. (1982). *Principles of Soil Chemistry. Terjemahan. Goenadi, D. H. dan B. Radjagukguk.* 1995. Dasar-dasar Kimia Tanah. Gajah Mada University Press. Yogyakarta. 295 hal.

Todano, T. & Yoshida, S. (1978). *Chemical Change in Submerged Soil and Their Effect on Rice Growth*. In: Soil and Rice. International Rice Research Institute, Manila. Phillipines.

Widdowson, J. P. (1990). The Impact of Surface Mining Activities on Soil and Water. In T. F. Rijnberg (Ed.) *Proceeding of the Joint Seminar on Environmental Impacts of Mining in Watersheed Management.* Bogor and Tanjung Enim, November 5 – 14th. Hal. 34 – 58.