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Reducing Exchangeable-Al and Increasing P Availability in Ultisol by the Application of Humic Compounds and Compost

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ABSTRACT

Lower production of crops on Ultisol soil in South Sulawesi was due to the inhibited vegetative growth of the crops. Such problem emerged as a result of high level of exchangeable-Al (Al_{exch}) in the soil, so that the crops would not be able to absorb sufficient nutrients from the soil. High concentration of Al_{exch} has caused the nutrients to be unavailable, particularly P. The application of humic compounds and compost, which contains organic compounds, will be able to improve and reduce the Al_{exch} level in the soil, so that they will be able to mobilize P in the soil. Objective of this research was to study the effect of humic compounds and compost of *Centrosema pubescens*, elephant grass, and chicken manure, on Al_{exch} change in the soil and the increased P availability in an Ultisol of the South Sulawesi. Results of the research showed that humic compounds and compost have been able to reduce concentration of Al_{exch} and increase P availability in Ultisol at the South Sulawesi. The application of the chicken manure compost has provided the best result in reducing concentration of Al_{exch} in the soil and increasing the available P in comparison with the application of humic compounds.

Key words: Al_{exch}, *P-available, compost, humic compounds, Ultisol*

INTRODUCTION

Ultisol in South Sulawesi is an acid soil (pH 4.9) that having high Al_{exch} level, 6.59 me/100g, total P 348.5 mg/kg, and available P 1.18 mg/kg [8]. Such high Al level will cause Al toxicity [12,17] and of course, it affects on growth and production of the crops. In general, Al is in insoluble form in the soil, but under pH <5, Al is in Al^{3+} form, which is toxic to plants [4,17].

The organic compounds of compost, such as humic compounds, can react to Al and forming organo-Al complex, so that it will reduce Al level in the soil [1,3,7,16,19,15,20]. Humic compounds and organic acids, which are contained in compost, are contain functional groups that have negative charged, such as: -COOH, -OH phenolate, and –OH alcoholate [2], so that they can bind cations, such as Al and Fe. Reduced Al_{exch} in the soil was due to Al settled in the form of $Al(OH)_3$ as a result of the increased pH in the soil and chelated by the functional groups of the humic compounds [6,10].

Formation of Al-organic complexes will affect P availability in acid soil, such as Ultisol. As stated by [19] that the decreased Al_{exch} in the soil by humic compounds has affected on P-soluble in the soil, both desorption and adsorption of P. [16] reported that the application of *Gliricidia* and *Tithonia* compost have significantly reduced the concentration of Al_{exch}, increased the level of $Al_{chelate}$, and increased the available P.

More organic material sources can be processed into compost, but it should consider their availabilities and abundance in the field. The organic

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material sources, such as *Centrosema pubenscens*, elephant grass, and the chicken manure, can be used as alternatives of compost materials in dry land and acid soil, such as Ultisol. The existence of such organic materials in South Sulawesi are abundant enough, particularly the chicken manure. Meanwhile, *Centrosema pubescens* has greater opportunity to be used as compost due to this plant is legumes, which has not been utilized optimally, besides that it is used as cover crops. As well as the elephant grass in South Sulawesi, this is used as forage crops due to it are abundant. Moreover, compost of these three organic materials contain high level of humic and fulvic compounds, as presented in Table 1.

Table 1: Characteristics of humic content and fulvic of the Centrosema pubescens compost, elephant grass, and chicken manure compost.

Type of Compost	Humic (mg/kg)	Fulvic (mg/kg) *)
Centrosema pubescens	940	1909
Elephant grass	1022	1777
Chicken manure	2278	2104

Notes: *) Based on result of HPLC analysis in the Laboratory of LIPI, Bogor, Indonesia

Based on these three composts, however, the chicken manure compost contains higher level of fulvic and humic compounds in comparison with composts derived from *Centosema pubercens* and the elephant grass. Objective of this research was to study the effect of humic compounds and compost of *Centrosema pubescens*, elephant grass, and chicken manure, in reducing Al_{exch} and increasing P availability in Ultisol at the South Sulawesi.

Materials and Methods

This research was conducted at the Laboratory in Faculty of Agriculture, Brawijaya Uiversity from May to July 2013. Materials of the research included Ultisol soil in South Sulawesi, *Centrosema pubescens* compost, elephant grass compost, chicken manure compost, humic compounds of the *Centrosome pubescens* compost, humic compounds of the elephant grass compost, and humic compounds of the chicken manure compost.

Humic compounds were obtained through fractionation of organic materials and extraction of fulvic and humic acids, which were adopted from IHSS (The International Humic Substances Society) that included: ten (10) g aerated dry compost (*Centrosema pubescens*, elephant grass, and chicken manure composts) was put into 250 ml centrifuge bottle, and then added 100 ml 0.1 N NaOH, and stirred for 24 hours. After that it would be centrifuged for 15 minutes at 10,000 rpm. Supernatant was sifted using Watman 42 paper as fulvic and humic acid solution. After that, 50 ml of the fulvic and humic acid solution was taken and added with high concentrated H_2SO_4 till pH of the solution was for about 2, stirred well and kept it overnight. At this stage, humic acid would settle down (precipitate). Separating fulvic and humic acids could be done through centrifugation at 6,000 rpm for 15 minutes, and then sifted using Watman 42 paper. And then the humic acid deposit would be dissolved with 0.1 N concentrated NaOH and left it for 2 hours.

Five hundred gram of Ultisol soil was put into 1 kg plastic pot, and then mixed with humic compounds and compost in accordance with the treatment, such as: 50 mL humic compounds of the *Centrosema pubescens* compost (HKC), 50 mL humic compounds of the elephant grass compost (HKR), 50 mL humic compounds of the chicken manure (HKA), 5 g compost of *Centrosema pubescens* (parallel with 20 t/ha) (KC), 5 g compost of elephant grass (parallel with 20 t/ha) (KR), 5 g compost of chicken manure (parallel with 20 t/ha) (KA), and control (distilled water) (K0), and then they were incubated for 63 days. Those seven treatments were arranged in a Randomized Complete Design by three replications. Al_{exch} (KCl 1 M) and available P (Bray II), was measured within 0, 7, 14, 28, 42 and 63 days. The obtainable data was analyzed using Microsoft Excel 2007, on the average of treatments, Anova, Duncan Multiple Range Test (DMRT), and graphic.

Result and Discussion

$Al_{exch:}$

The effects of humic compounds of the *Centrosoma pubescens* compost, humic compounds of the elephant grass, humic compounds of the chicken manure compost, and compost of the *Centrosema pubescens*, elephant grass, and chicken manure in Ultisol were highly significant in reducing Al_{exch} since the soil was incubated for 7 days and tended to be decreased in 42 days post-incubation (Table 2). Within 7 days post-incubation, the chicken manure compost has been able to reduce Al_{exch} for about 61.16% (to be 2.56 me/100g) of the previous level of Al_{exch} (6.59 me/100g) (Table 2), and then followed by the treatments of humic compounds of the chicken manure (Al_{exch} decreased 47.28%), and the lowest was treatment of *Censtrosema pubescens* compost (Al_{exch} decreased 23.28%) (Table 3).

Numbers followed by the same letter in the same column indicates no significant different between treatments by DMRT test $\alpha = 5\%$

In humic compounds treatment, the best treatment in reducing Al_{exch} in Ultisol at the South Sulawesi was humic compounds derived from chicken manure compost (HKA), and then followed by humic compounds that derived from elephant grass compost (HKR) and *Centrosema pubescens*

compost (HKC). As well as in compost treatment, chicken manure compost (KA) was the best treatment in reducing Al_{exch} in Ultisol at the South Sulawesi in comparison with composts that derived from elephant grass (KR) and *Centrosema pubescens* (KC). However, if the application of humic compounds from compost and direct application of compost in Ultisol were compared, Al_{exch} has reduced significantly during the application of compost, particularly the chicken manure compost (Table 2 and Table 3). Treatment using chicken manure compost (KA) was the most influential on Al_{exch} change in the soil. As presented in Table 3 that treatment using chicken manure compost has significantly reduced Al_{exch} in the soil since the soil was incubated from 7 days to 42 days. Al_{exch} has reduced greatly at 42 days of incubation for about 76.36% from the initial level of Al_{exch} in the soil (initial level of Al_{exch} in the soil was 6.59 me/100 g, has reduced into 1.56 me/100 g).

Table 2: The effect of humic compounds from *Centosema pubescens* compost, elephant grass, and chicken manure, as well as compost from *Centosema pubescens* compost, elephant grass, and chicken manure on Al_{exch} changes in the soil.

Treatment *)	Al_{exch} change (me/100g), during incubation (days)									
	7		14		28		42		63	
K0	6,59	e	6,59	d	6,59	f	6,59	e	6,59	c
HKC	4,57	cd	5,05	c	4,61	e	4,69	d	5,13	b
HKR	4,00	bcd	4,66	bc	4,14	cd	4,12	cd	4,92	b
HKA	3,43	ab	4,39	b	3,65	cd	3,82	cd	5,19	b
KC	5,06	d	4,70	c	4,26	d	4,61	d	4,97	b
KR	3,86	bc	3,40	b	3,58	b	2,85	b	4,85	b
KA	2,56	a	2,43	a	2,26	a	1,56	a	2,99	a

*) Treatments: K0: Control; HKC: Humic compounds of the *Centrosema pubescens* compost; HKR: Humic compounds of the elephant grass compost ; KHA: Humic compounds of the chicken manure; KC: Compost of *Centrosema pubescens;* KR*: C*ompost of elephant grass; KA: Compost of chicken manure.

Table 3: Percentage of the decreased Al_{exch} based on treatment of humic compounds and compost of the *Centrosema pubescens*, elephant grass, and chicken manure in accordance with the incubation period.

Treatment *)	Reduced Al_{exch} (%), during incubation (days)				
	7	14	28	42	63
K0	0.00	0.00	0.00	0.00	0.00
HKC	30.69	29.97	23.35	28.80	22.11
HKR	39.25	37.11	29.35	37.54	25.39
HKA	47.92	44.54	33.43	41.96	21.29
KC	23.28	35.28	28.63	30.10	24.57
KR	41.37	45.63	48.46	56.77	26.35
KA	61.16	65.74	63.11	76.36	54.57

*) see Table 2

The decreased Al_{exch} has related to the direct application of humic compounds in the soil, as well as the humic compounds in each compost (Table 1). By [1,3,20] stated that humic compounds could control high solubility of Al in acid soil. Such humic compounds could react to Al and forming complex compounds or Al complexation with the organic compounds, in which the simple Al chelation is formulated in reaction as follow:

$$3\ R\text{-}COO^- + Al^{3+} \rightleftharpoons 3(R\text{-}COO)Al$$

P availability:

The effect of humic compounds and compost of *Centrosema pubescens*, elephant grass and chicken manure have highly significant effect on the increasing P availability in Ultisol. P availability has increased optimally by the end of incubation, but the most significant increasing was seen at 28 days during the incubation (Figure 1). Treatment using chicken manure compost (KA) has given better P availability than other treatments, and followed by the application of humic compounds derived from chicken manure compost (HKA) and humic compounds from elephant grass compost (HKR) and *Centrosema pubescens* (HKC). The application of both *Centrosema pubescens* and elephant grass composts had less effect in increasing P availability in Ultisol at the South Sulawesi.

The increasing P availability has related to the application of compost into the soil. Application of the chicken manure compost, which contains the highest level of fulvic and humic acid, could increase P availability better than *Centrosema pubescens* and elephant grass composts. [9] stated that compost that contains high fulvic and fumic compounds would be able to increase P availability in acid soil. This is due to fulvic and humic compounds could dissolve minerals in the soil, so that an exchange between ligand of Al oxide and the organic acids has been able to increase P availability.

It was assumed that high fulvic acid contained in chicken manure compost (Table 1) has also affected the ability of such compost in increasing P availability in Ultisol. In accordance with [11], the ability of fulvic acid in releasing the absorbed P was higher than humic acid. As stated by [14] that fulvic acid has higher mobility than humic acid due to the molecular weight of fulvic acid is lower than humic acid. [9], organic materials that contained higher fulvic compounds have greater ability in increasing P availability in Ultisol. This was due to fulvic acid has

higher carboxyl level than humic acid, so that the fulvic acid has greater ability in forming complexes with cations in the soil in comparison with the humic acid.

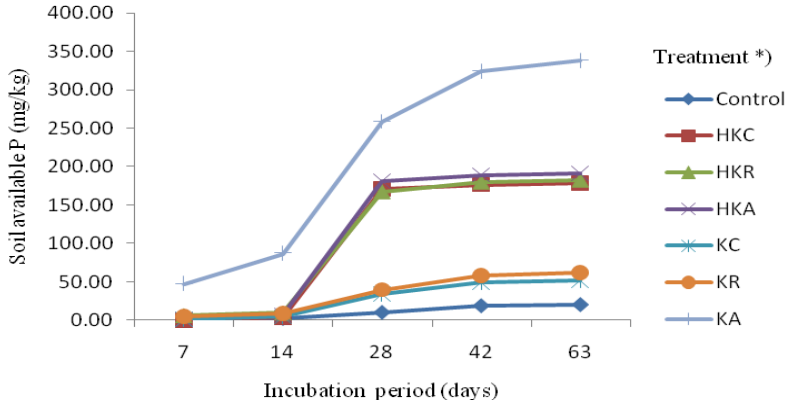

Fig. 1: The effect of humic compound derived from *Centrosema pubescens* compost, elephant grass, and chicken manure on P availability in Ultisol. *) see Table 2

The increasing P availability has close-related to the decreased concentration of Al_{exch} (Table 2 and Figure 1). Such close relationship has been described by [5], as well as [18], stated that the decreased activities of Al by humic compounds, which was resulted by ligand exchange of Al oxide with the organic acids through their functional groups to form the complex binds of organo-metal (chelate) with Al, so that the dependent P will be released and become available P. This chelation will reduce Al reactivity in P fixation. [13] stated that the organic anions of the organic compounds in the soil have been able to compete with the phosphate groups to bind with the binding sites in the soil so that P will keep independent or available. Then, it describes that these organic anions have transformed stronger complex with Al^{3+}, in comparison with the phosphate itself.

4. Conclusion:

The study showed that compost and humic compounds have been able to reduce Al_{exch} of the soil and increase P availability in Ultisol soil at the South Sulawesi. Application in the compost form in Ultisol is better in reducing Al_{exch} than application in the forms of humic compounds from the compost. The increasing P availability by the application of chicken manure compost has produced better results than other treatments.

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