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Using of Humic Matter from Low Rank Coal to Increase Phosphorous Fertilizer Efficiency and Production of Corn at Oxisol

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***Abstract*— The objective of this research was examined humic matter from low rank coal capability combined with P fertilizer to adsorp Al and Fe metal, to improve soil fertility, to increase of P fertilizing efficiency and productivity Oxisol, therefore optimalize productivity of corn can be achieved. The experiment was designed using a 3 x 4 factorial with 3 replications in design groups randomly. The 1st factor was 3 way incubating humic matter with P-fertilizer are : I1 = Incubation of humic matter 1 week, then incubation P-fertilizer 1 week; I2 = Incubation of humic matter and P fertilizer directly into the soil for 2 weeks; and I3 = humic matter and P fertilizer mixed for 1 week, then incubation to the soil for 1 week. The 2nd factor was humic matter and P-fertilizer combination are 4 doses H1=400 ppm (0.8 Mg ha-1)+ 100% R; H2 = 400 ppm + 75% R; H3 = 800 ppm (1.6 Mg ha-1) + 100% R; and H4 = 800 ppm + 75% R. The results showed that the best treatment interaction was founded 800 ppm humic matter and 100% R P-fertilizer doses in the first 3 way incubation that is corn yields increased from 4.53 Mg ha-1 (control) and 5.65 Mg ha -1 (farmer tradition) to 9.21 Mg ha -1.. However, this result is almost the same as 800 ppm humic matter + 75 % R P-fertilizer doses incubation with followed I3 way too. It was concluded that addition of humic matter and I3 incubation could be P-fertilizer save up to 25%.**

***Keywords*— Humate matter; low rank coal; P-Fertilizer; corn**

I. INTRODUCTION

The main problems encountered in the Oxisol (± 14.11 million ha or 7.5 % of the total land area of Indonesia) if used as agricultural land is primarily heavy metal toxicity of aluminium (Al) and iron (Fe) as well as nutrient deficiencies, especially phosphorous (P) in plants. Elements Al and Fe are much soluble in acid soil, it will be easy to bind P, so that the aexchition of P fertilizer is less beneficial for plants and P fertilization efficiency to become lower (Hardjowigeno, 2003).

To overcome the problem of heavy metal toxicity and P deficiency and to improve the efficiency of P fertilizer can be done with the addition of organic matter to the soil, but organic materials are often used as green manure and animal manure needs long enough weathering processes that require to be able reacted in the soil. Even the use of compost (organic matter is decomposed) still require further weathering processes in soil. Through this study using humic materials which is extracted from not productive low rank coal (subbituminous). Humic matter is the organic material components that rapid reaction, most active in the ground with electric charge and cation exchange capacity (CEC) which is greater than the clay mineral (Tan, 2003). Control of Al and Fe toxicity and increase the availability of P with the provision of humic materials can occur through the formation of a complex organo-metallic compounds or chelate, so the activity of metal Al and Fe which normally, binding P in the soil can be reduced and there is no toxic for plants. Directly humic matter can improve soil fertility by altering the physical conditions, chemical, and biological soil. Humic materials can modify medium of plants grow, which are increasing the formation of soil structure, increase soil water holding capacity and soil CEC (Stevenson, 1994; Fiorentino et. al., 2006 and Tan, 2010).

Another technology can be done to improve the efficiency of P fertilizer by incubation of P fertilizer and organic matter before it is given into the soil. Organic material will wrap fertilizer-P, or speed up dissolving fertilizer P, then P fertilizer is not in direct contact with the soil and quickly available, so that P fixation can be reduced (Herviyanti, and Gusnidar, 1999). This research using corn (Zea mays. L) as an indicator plant, because this plant has good prospects for mineral soils development like Oxisol and have a high response to P fertilization. Corn is a major food crop in Indonesia, a major component in livestock feed, industrial raw materials of food, corn oil, cornstarch and ethanol. Objective of this study is to examine the ability of humic materials from low rank coals that are not productive (subbituminous) in combination with P fertilizer (Orgin) as

well as the best application to the soil and to increase the efficiency of P fertilizer and corn production at Oxisol.

II. Material and Methods

Low rank coal was taken from Bonjol District, Pasaman Regency West Sumatra at 1-2 meters depth from the ground surface. This type of coal based on results of the experiment by Ahmad, Herviyanti, Gusnidar, and Rezki (2006) is Subbituminous. Low rank coal milled finely using stone smoothing machine (grondong), as much as 4 kg low rank coal and 20 liters of 0.5 N NaOH (ratio 1: 5) (modification the method of Tan, 1996), the tube is inserted into the machine and next the valve is covered. It is grounded for 3 hours and then filtered, the filtrate is humic material which will be treated in the Oxisol.

This research doing by field trials (plots) is performed directly in farmers' fields (in Padang Siantah District, Lima Puluh Kota Regency, West Sumatra) which is designed in the form of 3 x 4 factorial experiment with 3 replications were randomly groups design (RAK). The 1st factor was 3 way incubating humic matter with P-fertilizer are : I1 = Incubation of humic matter 1 week, then incubation P-fertilizer 1 week; I2 = Incubation of humic matter and P fertilizer directly into the soil for 2 weeks; and I3 = humic matter and P fertilizer mixed for 1 week, then incubation to the soil for 1 week. The 2nd factor was a combination of 4 levels of humic materials and P fertilizer which gives a better response from the greenhouse experiment by Herviyanti et. al. (2009), namely humic matter 400 ppm (0.8 Mg ha -1) + P fertilizer 75 % R (H1), 400 ppm + 100% R (H2), 800 ppm (1.6 Mg ha -1) + 75% R (H3), and 800 ppm + 100% R (H4). Recommendation (R) given P fertilizer was 300 kg ha -1 SP-36 (Prahasta, 2009). As a comparison was made plots of without humic materials and P fertilizer (control). In aexchition, to convince farmers fertilizing also done in keeping with tradition of local farmers. Two treatments is also done as much as 3 replications.

Tillage was done by plowing and hoeing the land to be planted, making plots measuring 3 m x 3 m by 1 m spacing between plots and 1.5 m distance between the groups. And then it was given humic materials and fertilizer P which was incubated in accordance with the treatment. Upon incubation of soil samples taken as much as ± 500 g for the chemical analysis of the soil after treatment.

Corn seed was planted at planting hole as much as 3 seed with a spacing of 75 cm x 25 cm and covered with soil. A week later the selection and left one of the best plants for each hole. Plant sampling for analysis of nutrient levels taken at the time of maximum vegetative growth (ages 63 days after plant), the number of samples taken 4 stem plots-1 (± 10% of the population per plot). The sample consists of the top of the plant (stems and leaves) and the bottom of the plant (root) by cutting the base of the stem at the root of the neck border. The roots and the stem of the plant are rinsed with distilled water, then input to oven at 600C for 2 x 24 hours, smoothed with a grinder. Levels of P plant nutrients was measuring by wet destruction method.

Harvesting was done when age plant at 107 days after plant (DAP), by picking corn in a cornhusk, cornhusk was peeled, seed cobs dried until dry, and then seed was weighed for dry weight measurement and calculated seed weight 14% water content.

Soil analysis has done by taken soil sample for preliminary and after incubation analysis include : H2O pH (1:1) with electrometrik method, available P with P-Bray II method, Al-exch analysis with the volumetric method, exchangeable Fe and Ca with ammonium acetate at pH 7 leaching.

III. Result and Discussion

A. Soil Analysis Results Once given the combination of humic matter and P Fertilizer on Some Ways Incubation.

1) Soil pH and Ca-exch

TABLE I
THE EFFECT OF THE COMBINATION OF HUMIC MATTER FROM LOW RANK COAL AND P FERTILIZER AND HOW TO INCUBATION ON H2O PH AND CA-EXCH

Incubation Method	The combination of humic matter (ppm) + P fertilizer (% Recommendation)				Average
	(400 +75)	(400 +100)	(800 +75)	(800 +100)	
	pH H_2O				
I_1	5.25	5.76	5.74	6.02	**5.69 a**
I_2	5.33	5.58	5.79	5.95	**5.67 a**
I_3	5.56	5.75	5.99	6.27	**5.89 a**
Average	**5.38 C**	**5.69 BC**	**5.84 AB**	**6.08 A**	
	Ca-exch (me (100 g) $^{-1}$)				
I_1	3.28	3.50	3.81	3.94	**3.63 b**
I_2	3.70	3.73	3.62	3.48	**3.64 b**
I_3	3.26	4.27	4.12	4.48	**4.03 a**
Average	**3.42 B**	**3.83 AB**	**3.85 AB**	**3.97 A**	
Control pH = 4.97 Ca-exch = 2.36					
Way farmers pH = 5.18 Ca-exch = 2.43					

The numbers in the same row followed by the same capital letter and in the same column followed by the same small letter are not significant different to HSD test at 5% significance level.

Note. I1 = humic matter incubated to soil for 1 week and then P fertilizer incubated for 1 week. I2 = humic matter and P fertilizer applied to the soil at the same time and incubated for 2 weeks. I3 = humic matter and P fertilizer were mixed for 1 week, then incubated for 1week to soil

From Table 1, it can be seen that treatment of combination from humic matter and P fertilizer at dose 800 ppm + 100% R has a pH value that is not significantly different from the dose of 800 ppm + 75% R. However, when it was compared with a dose of 100% + 400 ppm and 400 ppm + R 75% R increased soil pH respectively 0.39 and 0.70 on the unit three ways incubation. When compared with the controls and the way farmers, the value of the treated soil pH combination humic matter and P fertilizer in various ways incubation higher for all treatment combinations. This is consistent with the greenhouse experiments Herviyanti et. al. (2009), where the supply of 800 ppm of humic matter from low rank coal combined with P fertilizer doses of 75 and 100% recommendation on Ultisol from Harau district of Tanjung Pati Lima Puluh Kota Regency, could increase soil pH from 5.87 to 6.28 and 6.29 . Further research by Rezki (2009) on the Oxisol showed that the use of humic acid from

lignite (Subbituminous) at a dose of 2% C-organic can increase the value of a highly acidic pH (3.68) to moderately acidic (5,13).

The amount of Ca-exch on Oxisol were giving humic matter and P fertilizer, when incubated in many ways there is no interaction effect. The combination of humic matter and P fertilizer and the way of incubation have effect to Ca-exch of soil. The way incubation I3 is the best way to increase the amount of soil Ca-axch, there is an increase in Ca-exch as much as 0.39 me (100 g)-1 on incubation ways than I2, but the way incubation I2 Ca-exch value was not significantly different than I1 by incubation on some dose combination of humic matter and P fertilizer. Treatment of humic matter and P fertilizer on dose 800 ppm + 100% P can increase Ca-exch value is 0.55 me (100 g) -1 than treatment on dose 400 ppm + 75% R P fertilizer.

An increase on pH and Ca-exch value is also influenced by P fertilizer was aexched, because P fertilizer contain elemen of Ca which also dissolved Ca and have function to increase soil pH. Through the way incubation I3, more soluble P fertilizer because by mixing P fertilizer and humic substance before it incubating to the soil, there would be enough liquid and have a long time to dissolve the P fertilizer if compared with the treatment I2 and I1.

2) The content of soil Al and Fe-exch

TABLE II
INFLUENCE OF LOW RANK COAL HUMIC MATTER AND P FERTILIZER AND HOW TO INCUBATION ON AL AND FE-EXCH INTO THE SOIL .

Incubation Method	**The combination of humic matter (ppm) + P fertilizer (% Recommendation)**				**Average**
	(400 +75)	**(400 +100)**	**(800 +75)**	**(800 +100)**	
	Exch-Al (me (100) $^{-1}$)				
I_1	3.01	2.20	2.25	2.09	**2. 38 a**
I_2	3.07	2. 37	2.66	2.24	**2. 59 a**
I_3	2.88	2.62	1.96	1.77	**2. 31 a**
Average	**2.99 A**	**2.39 B**	**2.29 B**	**2.03 B**	
	Exch- Fe (ppm)				
I_1	57.45	55.21	61.82	53.69	**57.04 a**
I_2	67.81	58.46	54.50	57.14	**59.48 a**
I_3	60.29	56.84	56.03	53.48	**56.66 a**
Average	**61.85 A**	**57.45 AB**	**56.84 AB**	**54.77 B**	
Control Exch-Al = 3. 42 Exch- Fe = 70.35					
The way farmers Exch-Al = 2.98 Exch- Fe = 61.21					

The numbers in the same row followed by the same capital letter and in the same column followed by the same small letter are not significant different to HSD test at 5% significance level.

Combination of humic matter and P fertilizer treatment at dose 800 ppm + 100% R has lowest value of Exch- Al and have the same ability to degrade Exch-Al with a dose of 800 ppm + 75% R and 400 ppm dose + 100% R .This treatment can reduce soil Exch-Al of 0.96 me (100 g) -1 if it compared a dose to 400 ppm + 75% R. For the way incubation, lowest value Exch- Al found in I3, but not significantly different with I2 and I1. When it compared with the controls and the way of farmer, value of Exch-Al which were given a combination of soil humic matter and P fertilizers in various ways incubation also have lower value of exch-Al for all treatment combinations.

In Table 2 it can be seen that Exch-Fe content in the soil with incubation ways I1 nearly as I3 and I2 at some dose combination of humic matter and P fertilizer. While treatment of humic matter and P fertilizer at a higher dose to reduce the content of Exch-Fe bigger anyway, where on the dose 800 ppm + 100% Fe content has a lower at 7.08 ppm compared treatment 400 + 75%.

Increasing on pH value and decrease in Al and Exch-Fe by given combination of humic substance and P fertilizer, caused humic matter containing organic acids (humic acid and fulfic acid) be able to react with metals Al and Fe to form complex metal organo compounds or chelate so that activities of Al and Fe in soil solution can be reduce and soil pH value more higher. Higher amounts of humic matter given more functional groups that Al and Exch-Fe more reduce. According to Stevenson (1994) and Tan (2010) consists of humic materials like humic acid and fulvic acid that contains both phenol and carboxyl functional groups.

Decrease of Exch-Al also found in treatment mixing humic matter and P fertilizer for 1 week and then mix incubated to the soil during 1 week (I3). Allegedly this is due at the time humic matter and P fertilizer mixed first, makes Ca which is present in more soluble P fertilizers and to increase soil pH. Kaya (2003 in Kaya, 2009) give statement that higher P fertilizer makes Ca2+ ions in soil will more soluble in P fertilizers and will replace the H+, Al 3 + and Fe 3 + ion.

3) Available of P Content

TABLE III
INFLUENCE OF GIVING HUMIC MATTER (SUBBITUMINOUS) AND P FERTILIZER IN VARIOUS WAYS-INCUBATION OF THE AVAILABLE SOIL P (PPM)

Incubation Method	**The combination of humic matter (ppm) + P fertilizer (% Recommendation)**			
	(400 +75)	**(400 +100)**	**(800 +75)**	**(800 +100)**
I_1	18.70 a B	19.56 b B	23.54 b AB	32.40 b A
I_2	18.40 a B	22.53 ab AB	29.65 a A	34.09 ab A
I_3	20.60 a C	24.93 a BC	31.79 a AB	37.79 a A
Control = 7.61				
Way farmers = 11. 99				

The numbers in the same row followed by the same capital letter and in the same column followed by the same small letter are not significant different to HSD test at 5% significance level.

Best treatment can improve the value of P available is the way incubation I3 on the treatment of humic matter and P fertilizer combination on doses of 800 ppm + 100% R, but not significantly different from the dose of 800 ppm + 75% R, and increases P-available at 12.86 and 17.19 ppm if it compared to 400 ppm + 100% R and 400 ppm + 75% R. Increased of P-available in I3 ways incubation with increasing doses of humic matter and P fertilizer due to higher amounts of humic matter and the greater of its ability to increase the soil pH (Table 1), lower Al and Fe-exch (Table 2) and dissolve the P fertilizer. This mechanism happens because in I3 way incubation there is a significant decrease in Al-exch so that the binding was decreased and P-available increased and suspected by mixing humic materials and P fertilizer first, more P fertilizer dissolves and the time given to soil P becomes more available. When the compared

with the control and way of farmers having available P content 7.61 and 11.99 ppm, overall each treatment combination of humic matter and P fertilizer in various ways incubation showed a positive response and is able to improve P-available approximately 19.80 - 31.80 ppm.

Stevenson (1994) describes availability of P in the soil can be improved by the aexchition of organic matter through the action of organic acids or other chelating compounds decomposition, the release of phosphate that binds Al and Fe insoluble into soluble forms, would reduced the organic phosphate sorption as humic acid and fulvic acid serves to protect sesquioxida by blocking the sides of the exchange. Subsequently Nuryani, et al., (2000) explained that the 50-100 kg SP-36 fertilizer combination with organic materials capable increase the available soil P Oxisol. Increased P available estimated from the release of P was bounded by Al and Fe which are cluster very strongly adsorb P.

Based on the results of chemical analysis of soil that has been presented, it can be stated that the aexchition of humic matter combined with P fertilizer in various ways incubation can improve soil chemical properties, such as an increase in pH, nutrients available of P and Exch-Ca, otherwise the content of Exch-Al reduce. Especially when it compared to control and the way or farmers, in general, the treatment was given be able to improve the fertility of soil types Oxisol that will be planted with corn.

B. Observations Plants

1) Plant Height

TABLE IV
INFLUENCE ON GIVING HUMIC MATTER (SUBBITUMINOUS) AND P FERTILIZER IN VARIOUS WAYS INCUBATION OF CORN PLANT HEIGHT (CM)

Incubation Method	The combination of humic matter (ppm) + P fertilizer (% Recommendation)				Average
	(400 +75)	(400 +100)	(800 +75)	(800 +100)	
	High Corn				
I_1	143.67	161.33	158.00	173.33	**159.08 a**
I_2	126.67	142.00	15 7.33	148.33	**143.58 b**
I_3	163.00	161.67	178.67	185.00	**172.08 a**
Average	**144.44 B**	**155.00 AB**	**164.67 A**	**168.69 A**	
Control = 120.66			Farmers way = 129.00		

The numbers in the same row followed by the same capital letter and in the same column followed by the same small letter are not significant different to HSD test at 5% significance level.

Observation corn plant height were taken during the vegetative maximum of 63 DAP, interaction effect on giving humic matter and P fertilizer were incubated with various ways not significantly different with plant height. While the main effect showed significant differences on the growth of corn. In Table 4, it can be seen that the height of the corn plants treated with humic matter 800 ppm + 100% R of P fertilizer dose and on the third incubation manner similar to the dose of 800 ppm + 75% R and 400 ppm + 100% R, but amount of higher 24.45 cm compared to dose 400 ppm + 75% R. While incubation I3 of plant growth is higher 29.50 cm compared to the treatment I2 and almost the same as the treatment I1. There was increased corn plant height caused by the given of humic matter and P fertilizer to improve soil chemical properties such as pH, available P-content of the soil has increased as well as decreased soil Exch-Al, so that plant roots can develop better and can absorb more nutrients. Increasing was also allegedly caused by associated with the high amount of P absorbed by plants. Element of P was absorbed that used for root formation and plant growth. O'Donnell (1973 Cacco and Dell'Agnola, 1984 in Young and Chen 1997) proved that humic acids exhibit such activity for plant growth hormone, like auxin. Further research Young and Chen (1997) proved that giving of humic acid on lettuce seed can stimulate the growth of plant roots and plant dry weight. Results research from Roni, Soedarmadi and Setiadi (2002) indicate that there are interactions between humic acid and phosphate fertilizer in increasing P-available, plant height, leaf number trifoliat, canopy dry weight, and root dry weight.

2) P content on plants

Statistical analysis of the results on observation P content of plants is presented in Table 5, where influence of interaction humic matter and P fertilizer were incubated with various ways no significant effect on P content of corn plants. While the main effect of dose combination humic matter and P fertilizer and how incubation significantly affected levels of P both the roots and the top of the corn plant.

TABLE V
INFLUENCE GIVING HUMIC MATTER AND P FERTILIZERS IN VARIOUS WAYS INCUBATION OF THE P CONTENT OF ROOTS AND THE TOP OF THE PLANT (%)

Incubation Method	The combination of humic matter (ppm) + P fertilizer (% Recommendation)				Average
	(400 +75)	(400 +100)	(800 +75)	(800 +100)	
	Root				
I_1	0. 1 7	0. 2 2	0. 2 5	0.24	**0.22 ab**
I_2	0. 1 8	0. 1 8	0. 2 0	0.20	**0.19 b**
I_3	0. 2 2	0. 2 1	0. 3 3	0.30	**0.26 a**
Average	**0.25 BC**	**0.19 C**	**0.23 BC**	**0.26 AB**	
	The top of the plant				
I_1	12.13	12.13	12.14	12.16	**0.14 a**
I_2	12.12	12.13	12.13	12.14	**0.13 b**
I_3	12.12	12.13	12.14	12.17	**0.14 a**
Average	**0.12 C**	**0.13 BC**	**0.14 B**	**0.16A**	
Pcontent of plant roots Control = 0. 12 way farmers = 0. 21					
P content of the top plant Control = 0.06 way farmers = 0.09					

The numbers in the same row followed by the same capital letter and in the same column followed by the same small letter are not significant different to HSD test at 5% significance level.

In Table 5, it can be stated that the P content of corn roots in the treatment of 800 ppm humic matter + 75% R P fertilizer is almost equal to 800 ppm humic matter and P fertilizer 100% R. So that, P content of corn with giving of humic materials 400 ppm + 75% R P fertilizer almost as well as 400 ppm humic matter +100% R P fertilizer. Phosphorous levels found in giving optimum combination of 800 ppm humic materials and 75% R P fertilizer, which can increase levels of P roots and stems of corn is 0.06 and 0.02 % than 400 ppm + 75% R level. Similar effect was also obtained on treatment of I1 and I,. both levels of P for plant roots and stems of corn plants. Observations plant P levels

were obtained for all treatments was also in line with the increase available P (Table 3) in the soil.

3) Results Plants (seed weight with water content (WC) 14 %)

Results of analysis of variance showed that there was no significant interaction between giving humic matter and P fertilizer was aexched with 3 ways incubation on 14% seed weight train. The main effect of the combination of humic matter and P fertilizer and how to incubation significantly affected corn production as shown in Table 6.

TABLE VI
INFLUENCE OF HUMIC MATTER (SUBBITUMINUS) AND P FERTILIZER IN VARIOUS WAYS INCUBATION SEED WEIGHT WC 14% (MG HA -1)

Incubation Method	The combination of humic matter (ppm) + P fertilizer (% Recommendation)				Average
	(400 +75)	(400 +100)	(800 +75)	(800 +100)	
I_1	6.70	7.22	7.02	7.83	**7.19 ab**
I_2	6.06	6.70	6.77	7.20	**6.68 b**
I_3	6.00	6.99	8.44	9.21	**7.66 a**
Average	**6.25 C**	**6.97 BC**	**7.41 AB**	**8.08A**	
Control = 4.53 Ways farmers = 5.65					

The numbers in the same row followed by the same capital letter and in the same column followed by the same small letter are not significant different to HSD test at 5% significance level.

In Table 6, can be calculated that the highest corn grain yield of all treatments is the giving of humic matter 800 ppm + 100% RP fertilizer which are incubated in a way I3, the value is 9.21 t ha -1. The results obtained are very good results as above average corn crop varieties from 3 way (8.08 Mg ha -1) as well as approaching the potential yield of corn that can be achieved is 8.27 Mg ha -1. Nevertheless, the results are almost as good as the results obtained in the treatment of 800 ppm + 75% R. So that on the treatment 400 ppm humic matter, either in combination with 100% R and 75% R with P fertilizer showed almost the same results as well in a variety of ways incubation. This suggests that the administration of humic substance P fertilizer use can save up to 25%. Furthermore, when considered in Table 6, it can be stated that the giving of humic matter and P fertilizer mixed manner for 1 week prior to the soil and then it incubated for 1 week (I3) obtained the highest results in multiple dose of humic matter and P fertilizer. This means that in a way I3 incubation, the solubility of P was higher (Table 3), followed by a high P uptake as well (Table 5), so that the results obtained corn reached a value of 7. 66 Mg ha -1. When compared with the controls and the way farmers, providing a combination of humic matter at several doses and incubation ways to increase crop yields of corn were very noticeable from 4.53 and 5.65 to 8.08 Mg ha-1, this meaning an increase of 78.56 % and 43.01 % compared to controls and the way farmers. This suggests that a given farmer fertilizer P 100% R to the ground very little that can be absorbed by plant roots because without the humic matter, P fertilizer will be bound in the soil.

IV. CONCLUSIONS

The best treatment in reducing Al and Fe-ecxh to soil there was giving 800 ppm humic matter and 100% R P fertilizer by incubation I3, a decline value from 3.42 to 1.77 me (100 g) -1 for Al-ecxh and from 70.35 to 53.48 ppm for Fe-ecxh of soil.

The best treatments interactions that increased the availability of P soil and P nutrient content of corn is the way I3 incubation at providing a combination of humic matter and P fertilizer dose 800 ppm + 100%, almost the same as the dose of 800 ppm + 75%, and increases P-available for 17.19 and 12.86 ppm than dose 400 ppm + 100% R and 400 ppm + 75% R.

Treatment which is give the maximum yield of corn on 800 ppm humic matter and 100% R P fertilizer by incubation I3 , the amount of yield 9.21 t ha -1. However, this result is almost the same as giving 800 ppm humic matter + P fertilizer 75% recommendation by incubation I 3. This suggests that treatment of humic matter and P fertilizer can save up P fertilizer to 25%.

REFERENCES

[1] Ahmad, F, Effect of clay mineral and clay-humic acid complexes on availability and fixation of phosphate. Disertasi Doctor. University of Georgia. 221 pp, 1989

[2] Gusnidar, dan Rezki, Ekstraksi bahan humat dari batubara muda dengan menggunakan 10 jenis pelarut. Jurnal. Solum, Volume 3, No. 2 Juli 2006.

[3] Fiorentino, G., R. Spaccini, A. Piccolo, Separation of molekular constituens from a humic acid by solid-phase extraction following a transesterification reaction. Talanta 68, 1135-1142. 2006

[4] Hardjowigeno, S, Ilmu Tanah. Akademi Pressindo. Jakarta, 2003

[5] Harianti, M, Pengendalian Sorpsi Fosfat untuk Meningkatkan Desorpsi Fosfat pada Oxisol Padang Siantah Kab. Lima Puluh Kota dengan Aplikasi Bahan Humat. Tesis. Program Pascasarjana Universitas Andalas. Padang.117, 2009

[6] Herviyanti dan Gusnidar, Inkubasi pupuk SP-36 dan pupuk kandang untuk meningkatkan hasil jagung (Zea mays. L) pada Ultisol. Laporan penelitian SPP/DPP Unand. 29, 1999

[7] F. Ahmad, Gusnidar, dan A. Saidi.. Potensi batubara tidak produktif sebagai sumber bahan organik alternatif untuk meningkatkan efisiensi pemupukan Fosfor dan produksi agung pada tanah marjinal. Laporan Penelitian Hibah Kompetitif Sesuai Prioritas Nasional Batch II. 77, 2009

[8] F. Ahmad, T.B. Prasetyo, dan Darmawan, The Properties of humic acids exstracted from four sources of organic matters and their ability to bind Fe2+ at new established rice field. Journal of Tropical Soil Vol 15, No 3, September 2010. Hal 237-243, 2010

[9] Lutzow,M. V., Koegel-Knabner, I., Eckschmitt, E., Matzner, E. Guggenberger, G., Marscchner, B., and Fleesa, H, Stabilization of organic matter in temperate soils: mechanism and their relevance under different soil conditions. J. Soil Sci., 57, 426-445, 2006

[10] Nozoe.T, R.Agbisit, Y.Fukuta, R.Rodriguez, S.Yanagihara, The iron (Fe) excluding power of rice roots as mechanisme of toleran of elite breeding lines to iron toxicity. The International Rice Research Institute, Manila. Pp 1-5, 2004

[11] Rezki, D, Pengaruh Kompos, Asam Humat dari Batu Bara (Subbituminus) dan Pupuk Buatan Terhadap Tanaman Tomat (Lycopersicum esculenium Mill) pada Oxisol. Tesis. Program Pascasarjana Universitas Andalas. Padang, 2009

[12] Stevenson, F. J, Humus chemistry, genesis, composition, reactions. A Wiley-Interscience & Sons. New York. 496 p, 1994

[13] Tan, K. H, Soil Sampling, Preparation, and analysis. Marcel Dekker, Inc. New York. 408 p, 1996

[14] Humic Matter in soil and the environtment. Principles and Controversies. Marcel Dekker, Inc. New York. 386 p. 2003

[15] Principles of soil chemistry. Fourth Edition Revised and Expanded Marcel Dekker, Inc. New York. 362 p, 2010

[16] Yeo, A. R. dan T. J. Flowers,Soil mineral stresses approaches to crop improvement. Springer, Berlin Heidelberg. Jerman. 218, 1994