STUDY ON IMPROVEMENT OF INDONESIAN ACID SULPHATE SOIL: AMELIORANT FOR MASKING ALUMINUM TOXICITY IN RICE PLANT

Basuki Sumawinata, Gunawan Djajakirana, and D.P. Tejo Baskoro

Department of Soil Science and Land Resources, Facultuy of Agriculture,
Bogor Agricultural University
E-mail : tejo2baskoro@yahoo.com

ABSTRACT

The characteristic of the acid sulfate soils is very fragile; soil and water characteristic change rapidly in different time and condition. Soil pH changes from one site to other sites as well as from rainy season to dry season. The changing of soil pH affect most of other soil chemical properties such as solubility of Al, Fe and other nutrients in the soils. Usually improving low-pH soil is by application of lime. However, application of lime on acid sulfate soil is not suitable because needs much of lime and very low-pH water come periodically. Therefore, other methods to improve soil pH in acid sulphate soil should be created for rice cultivation. This research uses many kinds of soil ameliorant of rock phosphate, humic acid, and vulfic acid, etc for for masking Al in the rice fields. In the same time water management should be done to reduce the hazardous element of aluminum.

***Keywords**: acid sulphate soil, masking aluminum toxicity, rice production*

ABSORPTION OF Ca, K, Mg AND Na IN CORN ON THE OMBREGENOUS PEAT AS AFFECTED BY VOLCANIC ASH AND FLYING ASH

Eko Hanudin and Sri Nuryani Hidayah Utami

Laboratory of Soil Chemistry and Fertility, Department of Soil Sciences, Gadjah Mada University, Yogyakarta, Indonesia
E-mail : ekohanudin@ugm.ac.id

ABSTRACT

A pot experiment was conducted to investigate effect of volcanic ash and flying ash application on absorption of Ca, K, Mg and Na by corn hybrid C-1 on the ombrogenous peat (pH± 3.36, Al-exch 0.697 me% and H-exch 52.116 me%) from Pontianak., West Kalimantan. The treatment was arranged in 6 level (0, 10, 20, 30, 40 and 50 % by weight), in 3 replications. The results indicated that application of the volcanic ash and flying ash increased the corn growth. Shoot and root dry weight increased significantly with increasing amendment rate, but no significant effect of the soil amendment type. Uptake of Ca, K, Mg and Na in leaves, stem, roots and whole plant of maize are increased significantly with increasing amendment rate. The amount of cations which are mostly absorbed, and distributed in leaves was potassium (K), then followed by Mg, Ca and Na, but in the stem, the sequence were Mg > K > Ca > Na, and in the roots, were Na > K > Mg > Ca (for the volcanic ash treatment), and Na > Ca > K > Mg (for flying ash treatment), respectively. Almost all of the coefficient of correlation between Ca, K, Mg and Na absorption in whole plant and the soil amendments rate are significant, except for the relationship between the flying ash treatment and Na absorption.

Keyword: *Ombrogenous peat, corn, volcanic ash and flying ash*

INTRODUCTION

Indonesia is a tropical country which has the widest peat in the world (± 27 millions ha). A large part of peat in Indonesia is oligotropic peat and just a small part of peat is mesotropic and eutropic (Dressen .and Soepraptohardjo, 1974). Generally, the ombrogenous peat of Indonesia has acid reaction (pH-H_20 around 3,5 - 4,5), poor in nutrient and cation exchange capacity (CEC) is about 60- 240 me % (Dressen, 1978). The high CEC value of the ombrogenous peat is the result of the high content of functional group in organic acids, such as COOH, OH etc. Nevertheless, the macro nutrient content is relatively low.

The characteristic of peat is very different from mineral soils, therefore, the management needed is also different. According to Donahue *et al.* (1977), the management practice for peat is consisted of three important stages, namely 1). drainage 2). liming to increase pH of peat and 3). supply of nutrients to increase their fertility. But, the effort to overcome this problem with liming and fertilizer application is very costly. Therefore, attempts have been made to find an alternative that is cheaper, more effective and efficient. The use of natural goods (example: volcanic ash and flying ash) to improve the nutrient poverty is very rarely done.

The aim of this research is to observe how far the volcanic ash and flying ash are able to supply macro nutrients (Ca, K, Mg and Na) for plant growth on peat media.

MATERIALS AND METHOD

This experiment was conducted in a glass house. The peat was taken from Pontianak, West Kalimantan. Soil sampling was carried out at several points of a certain area and at the depth of 0 - 30 cm. After that, they were mixed to obtain a soil composite, and sieved by strainer with diameter of 5 mm. The indicator plant is corn hybrid C-1. The Volcanic ash was from Merapi Mountain and Flying ash was from PL TU Suralaya. Basal fertilizers used are Urea, TSP and KCL.

This experiment was arranged in completed randomized design, which consisted of 2 factors (Volcanic ash and Flying Ash). Each factor was made into 6 rates (0, 10, 20, 30, 40 and 50 %), and each treatment was made in 3 replications.

The chemical properties of soil measured were pH-H_20 and pH-KCI, organic matter contents, AI-exch, H-exch, Cations-exch (Ca^{2+}, K^+, Na^+ and Mg^{2+}), the total cations, effective CEC, and AI-saturation. The characteristics of amendment materials analyzed were pH-H_20 and pH-KCI, and the total cations (Ca^{2+}, K^+, Na^+ and Mg^{2+}) content. The plant tissue analysis was conducted using wet destruction method ($HClO_4$ 18 %) to see the total Ca^{2+}, K^+, Na^+ and Mg^{2+} content in leaves, stem and roots. The analysis of data was carried out by using MSTAT program for getting ANOVA and DMRT.

RESULTS AND DISCUSSION

Chemical properties of the peat and soil amendments

The chemical properties of the peat are presented in Table 1, and the chemical properties of Volcanic ash and Flying ash are in Table 2.

The acidity of this peat is very high because this soil is predominated by organic acids. Therefore, the exchangeable hydrogen content is higher than the exchangeable AI^{3+}. The exchangeable H^+ comes from organic acids, and the greater part of aluminum in the soil form ligand with organic matter, so the exchangeable AI^{3+} content is low. The advantage of this condition is that there is no problem with aluminium toxicity. The organic matter content in this soil is about 44.16%. The height of the organic matter can be used to store cations in the adsorption complexes.

The bulk density of this soil is very light (0.19 $g.cm^{-3}$), so that the rate of the exchangeable cations (Ca^{2+}, K^{+}, Mg^{2+} and Na^{+}) and total cations are high since the results were calculated based on weight. Actually, this rate does not show the real cations availability. Thus, the plant still needs much more cations to support its growth, unless they show a deficient symptoms.

The soil amendments used were volcanic ash and flying ash. The reaction of the flying ash is more basic than volcanic ash. Nevertheless, calcium oxide, potassium oxide, magnesium oxide and sodium oxide are higher in volcanic ash than in flying ash, therefore volcanic ash is counted as intermediate stone.

The Effect of Volcanic Ash and Flying Ash on Corn Growth

The growth of Corn can be improved by Volcanic ash and flying ash application. Table 3. shows that the raising of soil amendment rates can cause the plant's height, the weight of stem dry, roots dry and total plant dry to increase significantly. These indicate that the amendment can be used to improve the ombrogenous peat.

Table 1. Chemical properties of the peat for study Chemical properties

Chemical properties	Value
Bulk density (g.cm-3)	0.19
pH-H_2O	3.36
pH-KCI	2.56
Organic matter contents (%)	44.16
Al-exchangeable (me %)	0.70
H-exchangeable (me %)	52.12
Ca-total (%)	0.188
K-total (%)	0.039
Na-total (%)	0.035
Mg-total (%)	0.079
Ca-exchangeable (me %) K-	6,78
exchangeable (me %) Na-	1.70
exchangeable (me %) Mg-	2.45
exchangeable (me %)	4.40
CEC-effective (me %)	16.04
Saturation AI (%)	4.35
Sum of base cations (me %)	15.34

Explanation: These data were calculated based on air dry weight (Moisture content: 118,64 %)

Table 2. Chemical properties of Volcanic ash and Flying Ash

Chemical properties	Value
1. Volcanic Ash	
$pH\text{-}H_2O$	5.86
pH-KCl	4.91
CaO-total (%)	1.725
K_2O-total (%)	0.240
MgO-total (%)	0.847
Na_2O-total (%)	1.295
2. Flying Ash	
$pH\text{-}H_2O$	9.62
pH-KCl	9.59
CaO-total (%)	0.447
K_2O-total (%)	0.123
MgO-total (%)	0.585
Na_2O-total (%)	0.316

Table 3. The effect of Volcanic Ash (AV) and Flying Ash (AT)

Treatments	High(cm)	Stem-DW(g/pot)	Roots-DW(g/pot)	Total-DW(g/pot)
AVO (0 %)	51.500 a	1.210 a	0.167 a	1.377 a
AV1 (10 %)	138.667 b	6.440 b	2.370 b	8.810 b
AV2 (20 %)	176.667 c	24.300 c	4.800 c	29.100 c
AV3 (30 %)	198.500 cd	33.320 d	8.303 de	41.623 d
AV4 (40 %)	199.667 cd	43.720 e	9.453 e	53.173 e
AV5 (50 %)	221.667 d	52.037 f	10.357 e	62.394 f
Average	164.445	26.838 B	5.908 C	32.746 D
ATO (0 %)	55.333 a	1.187 a	0.203 a	1.390 a
AT1 (10 %)	90.333 b	9.726 b	0.573 a	10.299 b
AT2 (20 %)	161.167 c	23.173 c	2.917 b	26.090 c
AT3 (30 %)	199.500 d	31.356 d	5.897 c	37.253 d
AT4 (40 %)	207.000 d	48.607 e	8.687 d	57.294 e
AT5 (50 %)	217.500 d	49.823 e	8.510 d	58.333 e
Average	155.139 A	27.312 B	4.465 C	31.777 D

Explanation: number followed by the same letter show that it is nonsignificant at 5% confident level

Concentration and Absorption of Ca, K, Mg and Na in the Plant as Affected by Volcanic Ash and Flying Ash

Uptake of Ca, K, Mg and Na that are distributed in leaves increase significantly with the increasing of the rate of the soil amendments applied (Table 4.), but their concentration in leaves is not influenced significantly. The amount of cations which most absorbed by leaves is Potassium (K), then it is followed by Mg, Ca and Na. The same case occurred in stem, roots and the whole plant (Table 5, 6 and 7), but the sequence of cations up taken by the stem and roots are different. The most cations absorbed by stem is Mg, and then are followed by K, Ca, and Na. In the roots, the effect of Volcanic ash and flying ash application are different in the sequence of the amount of cations absorption. On the Volcanic ash treatment, the most cations up taken is Na, then it is followed by K, Mg and Ca, while, the order on the flying ash treatment is Na, Ca, K and Mg.

The coefficient of correlation between Ca, K, Mg and Na absorption in the whole plant and the soil amendments rate is presented in Table 8. Almost all of the r value are significant, except for relationship between the flying ash treatment and Na absorption.

CONCLUSIONS

Application of volcanic ash and flying ash as soil amendments were able to improve the chemical properties of the ombrogenous peat and the corn growth. All of the dry weight of the agronomic components indicated increase significantly with increasing soil amendment rates. Absorption of Ca, K, Mg and Na in leaves, stem, roots and whole plant also increased significantly with increasing soil amendment rates. On the other hand, the cations concentration in the plant were not increased significantly. The amount of K absorption in the leaves was higher than Mg, Ca and Na. Whereas, their absorption in the stem was Mg > K > Ca > Na, and in the roots, was Na > K > Mg > Ca (for the volcanic ash treatment), and Na > Ca > K > Mg (for flying ash treatment). Almost all of the correlation coefficient (r) between the Ca, K, Mg and Na absorption in the plant and the soil amendments rate were significant, except the relationship between the flying ash treatment and Na absorption.

REFERENCES

Chang, A. C., L. J. Lund, A. L. Page & J. E. Warneke. 1977. Physical Properties of Fly Ash-amended Soils. J. Environ. Qual. 6 : 267 - 270.

Cottenie, A., Verloo, M., Kiekens, L., Velghe, G & Camerlynck, R. 1982. Chemical Analysis of Plant and Soils. Laboratory of Analytical and Agro chemistry, State University of Ghent, Belgium, 63 p.

Davison, R. L., D. F. S. Natush, J. B. Wallace & C. A. Evans. 1974. Trace Elements in Fly Ash: Dependence of Concentration on Particle Size. Environ. Sci. Techno!. 8 : 1107 - 1113.

Driessen, P. M. & M. Soepraptohardjo. 1974. Soil for Agricultural Expansion in Indonesia. Bull. 1 ATA 106. Soil Res. Inst., Bogor. 63 p.