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Phosphorus and Micronutrient Status in Paddy Soils from Jogjakarta, Indonesia

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Abstract

The content and distribution of P (available and potential) vertically and horizontally in the intensive paddy field already reached a high-very high rate. The content of the P fractions in the plowed layer from the 6 study areas as follow: 1). P-saloid: Moyudan > Sedayu > Sanden > Godean > Lendah > Sentolo; 2). Al-P: Godean > Moyudan > Sedayu > Sentolo > Sanden > Lendah; 3). Fe-P : Moyudan > Godean > Sedayu > Lendah > Sentolo > Sanden; 4). Ca-P: Godean > Sentolo > Lendah > Moyudan > Sedayu > Sanden; 5). P-reducted: Sanden > Sentolo > Lendah > Moyudan > Sedayu > Godean; 6). P-occluded: Sentolo > Sanden > Lendah > Godean = Moyudan > Sedayu, respectively. Whereas, the distribution of the P fractions in the subsoil layer as followed: 1). P-Saloid: Godean > Sedayu > Sentolo > Moyudan = Lendah > Sanden; 2). Al-P: Godean > Moyudan > Sedayu > Sentolo > Sanden > Lendah; 3). Fe-P: Godean > Moyudan > Sedayu > Lendah > Sanden > Sentolo; 4). Ca-P: Godean > Lendah > Sedayu > Moyudan > Sentolo > Sanden; 5). P-reducted: Sanden > Moyudan > Lendah > Godean > Sedayu > Sentolo; 6). P-occluded: Lendah > Sanden > Sentolo > Sedayu > Moyudan = Godean. The mentioned P fractions are not available for plant growth. The concentration of Zn and Cu in the paddy soils were catagorized as a moderate level. It means that the both micronutrients were found to be sufficient for plant growth. This finding implied that the excessive amount of soil-P did not decrease significantly the Zn and Cu availabily. However, the amount of fulvic acid in the soil may have a contribution to the Zn and Cu availability.

Key words: Paddy soil, P fractions, organic matter, Zn and Cu availabily, and fulvic acid.

Introduction

Around 1960 Indonesian Government established "BIMAS Program" to accelerate a rice production. During period of 1989 – 1993, production and productivity of rice increased sharply. After 1993, the rice production increased not significantly, whereas the productivity was getting maximum point at around 4,6 ton.ha^{-1} (Sofyan *et al*., 2004). Contenously application of TSP more than 30 years resulted in accumulation of P in the intensive paddy soils. Threfore, a rice growing in the paddy soils in which status of P with moderate-hight level are not responded to P fertilization. Leveling off the productivity of the paddy soils due to intensive P fertilization indicated decreasing a fertilization efficiency (Prasetyo *et al*., 2001; Sofyan *et al*., 2004). The excessive use of P fertilizer yielded an abundance of soil-residual P, which in turn, may reduce the availability of Zn ($3Zn^{++} + 2\ H_2PO_4^- + 4\ H_2O \rightleftharpoons Zn_3(PO_4)_2.4H_2O + 4H^+$) or the availability of Cu ($3Cu^{++} + 2\ H_2PO_4^- + 2H_2O \rightleftharpoons Cu_3(PO_4)_2.2H2O + 4H^+$ (Lindsay, 1979). Zink and Cu are micronutrients which play an important role on enzyme activator and auxin biosynthesis. The shortages of both micronutrients will directly retard the crop growth and decrease the crop yield

The objectives of this study was to find out the content and distributions of P fractions (P-potential, P-available, Saloid P, Al-bound P, Fe-bound P, Ca-bound P, reductant soluble P, and occluded-P) and Zn-Cu-available in the intensive paddy soils from Jogjakarta, Indonesia.

Materials and Methods

The study was conducted at six sites of a rice fields (Sanden, Sedayu, Moyudan, Godean, Lendah and Sentolo areas) in Jogjakarta, where the rice has been cultivated intensively. The soil samples were taken from four layers in a depth of 0-15 cm, 15-30 cm, 30-45 cm, 45-60 cm, respectively. The depth of 0-30 cm as a representative of a plowed layer and 30-60 cm as a representative of a subsoil. Physical and chemical analysis was conducted for pH, C-organic (Walkey and Black method), Humic Acid, Fulvic Acid, CEC (NH_4OAc saturation method), texture, Zn-available and Cu-available (DTPA). Beside P-potential (HCl 25%) and P-available (Bray I), fractionation of P was also conducted for Saloid P (1M NH_4Cl), Al-bound P (0.5M NH_4F), Fe-bound P (0.1M NaOH), Ca-bound P (0.25M H_2SO_4), reductant soluble P (mixture of 0.3M Na-dithionite and Na citrate solutions), and occluded-P (0.1M NaOH) (Tadesse *et.al.*, 1991). Metal elements were analyzed by AAS, and P with colorimetric method. The content and distribution of the P fractions may be correlated to the history of soil management, cropping system, and soil productivity.

Results and Discussion

Soil texture from the 6 location could be categorized at range of silty clay-clay, except for soil from Godean which has a sandy loam texture. By following the rate of soil chemical properties was established by Indonesian Soil Research Institute (2005), soil reaction in the 6 location almost not so different, pH-H_2O observed at range of 5.67-7.49 (slightly acid-neutral). Organic matter content observed at range of 0.9-3.2 % (very low-low). The content and distribution of P vertically and horizontally in the intensive paddy field already reached a high-very high rate. However the P forms in the paddy soil was not all in the available form (orthophosphate), mostly in a stable form. The majority of phosphate fertilizer applied to soil was adsorbed by colloid particles, such as clay, Fe-oxide, Al-oxide etc. If the orthophosphate ion adsorbed by the mineral colloid and form an *innersphere complex* (Essington, 2004) resulted in the phosphate ion is difficult to be absorbed by plant. Potential P (P extracted HCl 25%) content in the plowed layer of paddy soil from 6 locations observed at range of 162-173 ppm, and in the subsoil was at range of 154-173 ppm. This indicated that concentration of P-potential in majority of the paddy soil in Jogjakarta has a very high rate. Actually, the amount of soil P was extracted by HCl 25% composed of P in solution, P-labile, P-metastable and P-stable. Normally, application of organic matter or humic substances could accelerate releasing of P from the adsorption complex. Bray I was used as an extractant for predicting the availability of P. The concentration of the P-available in the plowed layer and in subsoil was observed at same range of 12–14 ppm (high). This indicated that distribution of the P-available horizontally and vertically almost similar. Study further about a phosphate complex forms, fractionation of P was also conducted for observing some P fractions. The content of saloid P, Al-bound P, Fe-bound P, Ca-bound P, reductant soluble P, and occluded-P in the plowed layer was observed at range of 1-12, 7-24, 9-64, 10-70, 35-90 and 101-157 ppm, respectively. Whereas the content of the P fractions in the subsoil was at range of 2-25, 9-28, 20-95, 11-93, 28-55 and 99-132 ppm, respectively. The other chemical properties may posses a contribution to the availability of P, such as fulvic acid, humic acid, Zn and Cu in the plowed layer was observed at a range of 96-385, 149-481, 40-105 and 14-75 ppm, respectively. Whereas in the subsoil was at range of 245-516, 44-402, 42-118 and 10-30 ppm, respectively. If we compare the P fractions content from the 6 study areas in the plowed layer as follow: 1). P-saloid: Moyudan > Sedayu > Sanden > Godean > Lendah > Sentolo; 2). Al-P: Godean > Moyudan > Sedayu > Sentolo > Sanden > Lendah; 3). Fe-P : Moyudan > Godean > Sedayu > Lendah > Sentolo > Sanden; 4). Ca-P: Godean > Sentolo > Lendah > Moyudan > Sedayu > Sanden; 5). P-reducted: Sanden > Sentolo > Lendah > Moyudan > Sedayu > Godean; 6). P-occluded: Sentolo > Sanden > Lendah > Godean = Moyudan > Sedayu, respectively. Whereas, the distribution of the P fractions in the subsoil layer as followed: 1). P-Saloid: Godean > Sedayu > Sentolo > Moyudan = Lendah > Sanden; 2). Al-P: Godean > Moyudan > Sedayu > Sentolo > Sanden > Lendah; 3). Fe-P: Godean > Moyudan > Sedayu > Lendah > Sanden > Sentolo; 4). Ca-P: Godean > Lendah > Sedayu > Moyudan > Sentolo > Sanden; 5). P-reducted: Sanden > Moyudan > Lendah > Godean > Sedayu > Sentolo; 6). P-occluded: Lendah > Sanden > Sentolo > Sedayu > Moyudan = Godean.

Conclusion

The content and distribution of P vertically and horizontally in the intensive paddy field already reached a high-very high rate. The concentration of Zn and Cu in the paddy soils were categorized as a moderate level. It means that the both micronutrients were found to be sufficient for plant growth. This finding implied that the excessive amount of soil-P did not decrease significantly the Zn and Cu availabily. However, the amount of fulvic acid in the soil may have a contribution to the Zn and Cu availability.

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