Effect of P-Fertilizer and Organic Matter to Value of pH and pHo, P-availability, and Yeild of Mieze in Andisols from Pangalengan West Java

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Abstract. One of the problems in the utilization of Andisols for agriculture is their high retention of phosphate by allophane mineral which has variable charge. Such phenomenon can be reduced by giving high phosphate fertilizer or increasing organic matters. This research aimed to understand the effect of dose of P fertilizer and types and dose of organic matter fertilizers to reduce P-Retention and soil pH₀ on Andisols planted with sweet corn, so the efficiency of phosphate fertilizer utilization could be achieved. This research was conducted in glasshouse experiments using Completely Randomized Design respectively. The result showed there were no interaction effects between phosphate and organic matters on P retention, P total, P availability, P uptake, pH and pH₀. Optimal dose of phosphate fertilizers for sweet corn was 45 kg/ha P₂O₅ for all organic matter fertilizers.

1. Introduction

Andisols or Andosol in Indonesia, according to the National Soils Classification System, has an area of around 5.4 million ha or 2.9% of total mainland in Indonesia [1]. Andosol are soils with ABwC horizons, have a molic or umbric horizon aboved B cambic horizon, and have one or both of requirements in the depth of ≥ 35 cm: (a) bulk density < 0.90 g/cm and dominated by amorphous materials, (b) > 60% volcanic ash or pyroclastic materials [2]. Andisols generally located in the agroecosystem zones in which they are used for tea plantation or vegetable farming in highland. The problem that often arises in this soil type is low plant productivity due to its chemical characteristics, such as high P-retention, high leaching of bases, and its physical characteristics, such as susceptible to erosion [3].

Low phosphate content in the Andisols can be caused by strong fixation of P by hydrous oxide or silicate clay and suspended by Fe, Al, and Mn ions [4]. High P fixation is also due to the presence of dominated allophane and imogolite minerals which strongly retain P in their exchange complex. Allophane minerals have P sorption capacity almost hundreds fold than gibbsite [5,6]. This type of mineral is also amphoteric and they are able to retain phosphate in huge amount [7].

The decrease of phosphate retention can be done by lowering zero point of charges (ZPC) or pH₀ value. ZPC emerge due to amphoteric characters in their oxides and or iron/Al oxides and Allophane or other amorphous materials in clay fractions which are the main character of clay with variable charges [8]. The decrease of ZPC can increase the surface of negative charge and increase cation exchange capacity after phosphate application. In addition, an increase of organic matter content is also one of the ways to decrease ZPC [9]. These processes occur because organic anions are absorbed to the surface of particles, then they cover some of the positif charges on the surface, so cations retention increase.

Organic matter affected in plant growth with its effect to chemical, physic, and biological soil properties [10]. A high dose of organic matter application would increase the release of cations to the
soil solution, so it could maintain or even increase pH [11]. Humus as a result of decaying organic matter is one of the components with variable charge in which the release of cations and anions from mineralization of organic matter can increase electrolyte concentration [10]. This process has an effect to the decrease of potential surface or pH, yet increase soils’ cation exchange capacity.

The crops in allophanic soil need higher of labile P, it is important to manage the P sorption capacity of allophane and other Al compound to increase the supply of labile P [12]. Addition of organic manure along with inorganic P could increase the available of P in soil [13]. Phosphorus (P) availability from manure (all type of animal production sources) is high (> 70%) [14]. Poultry manure more readily supplies P to plants than other organic manure sources [12].

In term to increase crop production, the integration of mineral fertilizers with organic amendments (e.g. animal manure and compost) is recommended [15]. However, this is a challenge for the farmer that fertilizers are expensive. It will urge the needs of researches to find alternative doses and types of organic matter in order to have an efficiency manure usage. This research aimed to understand the effect of dose of P fertilizer and types and dose of organic matter fertilizers to reduce P-Retention and soil pH on Andisols planted with sweet corn, so the efficiency of phosphate fertilizer utilization could-be-achieved.

2. Materials and Methods
The research was greenhouse experiment that conducted in experimental farm of Agriculture Faculty, Jatinangor, Sumedang District, West Java. Sweet corn (Zea mays saccharata Sturt) was used as an indicator plant. The greenhouse experiment used Completely Randomized Design with factorial pattern consisting of 2 factors and 3 replicates. Treatments design consist with: P₂O₅ doses as first factor, and type of organic matter as second factor. First Factor : a₀ = 0 kg/ha P₂O₅, a₁ = 45 kg/ha P₂O₅, a₂ = 90 kg/ha P₂O₅, a₃ = 135 kg/ha P₂O₅, a₄ = 180 kg/ha P₂O₅. Second Factor : b₀ = without organic matter; b₁ = 4 t/ha cow manure, b₂ = 4 t/ha chicken manure, b₃ = 4 t/ha sheep manure, b₄ = 4 t/ha rice straw compost.

Data were analysed with analysis of variance. The difference of treatment means was analyzed with F-test at the level of significance of 5%. If the results of F-test showed real difference between treatments, they were further tested by the smallest real difference-test (BNT). Observation in the greenhouse experiment included soil pH, P-retention, P-potential, P-Bray, P-uptake, pH₀, and weight of sweet corn.

3. Result and Discussion

3.1. P-retention, P-total, P-availability, and P-adsorption
Table 1 showed that application of P fertilizer up to the dose of 180 kg/ha P₂O₅ did not affect P-retention. However, P-retention tended to increase as an increase of P fertilizer doses. This situation can be related to the balance of P in the soils. Some of the factors that affect P-retention are the amount of allophane and imogolite minerals [12,16,17] and associated Al or Fe oxide with humic substance [18].

Organic matter has a high content of humic acid [19], this humic substance resulted from biochemical evolution during decomposition of organic substrates [10]. Humic substance can increase the soluble and extractable P [20]. The role of organic matter can affect available of through its organic acid content which can increase the number of negative charges in soil colloids [21]. Organic anions are known to compete with P and occupy fixation locations in which can decrease the ability of soils to retain P [22-24]. Based on Table 1, organic matter application affected to P-retention. Application of 4 ton/ha organic matter could decrease the P-retention from 78.9% to 65.9-73.2%, depend on organic matter type. Chicken manure can decrease P-retention up to 16.5% rather than other organic matter types.

Application of cow manure with dose of 4 ton/ha was not significantly different with control (without organic matter) in P-total, but was significantly different with other organic mater types (Table 1). Availability of Phosphate and its quantities are different between animal manures [25, 26]. In acidic soil, cow manure could change soil pH and increase P availability [27]. In addition, P fertilization also did not increase P-availability in Andisols. This is in line with the result of P-total.
The numbers followed by the same letter are not difference according to the Duncan Multiple Range Test at 5%

3.2. $pH$ dan $pH_0$
Application of organic matter did not influence soil pH in sweet corn field environment (Table 2).

Table 2. Independent Effect of P Fertilizer and Organic Matter to pH, $pH_0$

| Treatments                        | Mean of pH | Mean of $pH_0$ |
|-----------------------------------|------------|----------------|
| $a_0$ (0 kg/ha P$_2$O$_5$)        | 5.13 a     | 4.51 a         |
| $a_1$ (45 kg/ha P$_2$O$_5$)       | 5.17 a     | 4.51 a         |
| $a_2$ (90 kg/ha P$_2$O$_5$)       | 5.11 a     | 4.51 a         |
| $a_3$ (135 kg/ha P$_2$O$_5$)      | 5.13 a     | 4.48 a         |
| $a_4$ (180 kg/ha P$_2$O$_5$)      | 5.21 a     | 4.52 a         |
| $b_0$ (Without organic fertilizer)| 5.15 a     | 4.51 a         |
| $b_1$ (4 ton/ha cow manure)       | 5.15 a     | 4.49 a         |
| $b_2$ (4 ton/ha chicken manure)   | 5.15 a     | 4.47 a         |
| $b_3$ (4 ton/ha sheep manure)     | 5.11 a     | 4.52 a         |
| $b_4$ (4 ton/ha rice straw compost)| 5.17 a     | 4.53 a         |

The numbers followed by the same letter are not difference according to the Duncan Multiple Range Test at 5%

Andisols have a higher buffering capacity because of dominancy of allophane materials and their colloids, beside that application of organic matter could increase the buffer capacity [28]. Meanwhile, C-organic content naturally had negative correlation with pH in Andisols soils in tea plantation, West Java [6].

3.3. *Plant Yields (Weight of Stem and Stem + Cornhusk)*
Application of P fertilizer and organic matter types did not influence plant yield (Table 3). Nevertheless, application of P fertilizer could decrease the yield while organic matter tended to increase the yield. This can be expected due to low dose materials in the application (P fertilizer and organic matter), so P-uptake did not have a significant effect. However, P fertilizer is needed for the assimilation process and building up energy in the photosintate formation.
Table 3. Independent Effect of P Fertilizer and Organic Matter to Stem Weight and Stem + Dry Cornhusk

| Treatments                          | Mean Stem (g) | Mean Stem +Dry husk (g) |
|------------------------------------|--------------|-------------------------|
| a₀ (0 kg/ha P₂O₅)                  | 164.32 a     | 203.85 a                |
| a₁ (45 kg/ha P₂O₅)                 | 168.87 a     | 206.71 a                |
| a₂ (90 kg/ha P₂O₅)                 | 158.76 a     | 201.16 a                |
| a₃ (135 kg/ha P₂O₅)                | 162.51 a     | 202.31 a                |
| a₄ (180 kg/ha P₂O₅)                | 162.93 a     | 202.05 a                |
| b₀ (Without organic fertilizer)    | 160.31 a     | 202.29 a                |
| b₁ (4 ton/ha cow manure)           | 166.91 a     | 202.87 a                |
| b₂ (4 ton/ha chicken manure)       | 164.77 a     | 205.82 a                |
| b₃ (4 ton/ha sheep manure)         | 163.21 a     | 203.71 a                |
| b₄ (4 ton/ha rice straw compost)   | 162.19 a     | 201.39 a                |

The numbers followed by the same letter are not different according to the Duncan Multiple Range Test at 5%

P-uptake tended to increase with increasing level of dose of P fertilizer compared to no P fertilizer (control). This condition shows that sweet corn plants give respond toward P, but it is not sufficient to cause a difference in the P-uptake. It relates with low of P-availability (Table 1) in supplying P nutrients to the growth and development of roots.

4. Conclusions
P fertilizer and organic matter have no interaction on the P-retention, P-total, P-availability, P-uptake, and corn yield. Application of P fertilizer independently did not affect all the response variables while organic matter only affects on P-retention and soil P-total. There is a need of further research related to the effect of types of organic materials in various series of Andisols

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