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Improvement of Soil Chemical Properties of *Typic Hapludult* After Application of Organic and Inorganic Fertilizers

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ABSTRACT

Tuberose (*Polyanthes tuberosa* L.) is a potential flowering plant that will be developed in Jatinangor, West Java, Indonesia. However, the characteristics of *Typic Hapludult* soil in Jatinangor, *i.e.* clay texture, acidic pH, and high amount of total-P but low in available-P cause the tuberose difficult to grow optimally. The aim of this study was to obtain the potential ratio of organic and inorganic fertilizer dosages for tuberose grown on *Typic Hapludult*. The combinations of organic and inorganic fertilizers with different ratios (0/0; 0/1; 1/0; 0.5/0.5; 0.5/1; 1/0.5; 1/1.5; 1.5/0; 1.5/0.5, and 1.5/1) were applied. The application of the combination of organic and inorganic fertilizers showed positive effects on soil pH, available-P, total-P, and fresh weight of tuberose grown on *Typic Hapludult*. The application of 50% organic fertilizer + 50% inorganic fertilizer was an effective combination that was able to increase the fresh weight of tuberose up to 9240 g plant⁻¹ or increasing the fresh weight by 39% in comparison to that in the control treatment (without fertilizer application).

Keywords: Fresh weight, inorganic fertilizer, organic fertilizer, tuberose, *Typic Hapludult*

ABSTRAK

Tanaman sedap malam (*Polyanthes tuberosa* L.) merupakan salah satu jenis tanaman hias berbunga indah yang potensial untuk dikembangkan di Jatinangor. Namun, tanah *Typic Hapludult* yang umumnya berada di Jatinangor memiliki tekstur tanah yang liat, reaksi tanah asam, dan tingkat P-total yang tinggi, namun kandungan P-tersedia yang rendah. Hal ini akan menghambat pertumbuhan tanaman sedap malam. Tujuan dari penelitian ini adalah untuk mendapatkan komposisi pupuk organik dan anorganik yang potensial untuk pertumbuhan tanaman sedap malam pada tanah *Typic Hapludult*. Penelitian ini menggunakan pupuk organik dan anorganik dengan komposisi dan rekomendasi dosis yang berbeda (0/0; 0/1; 1/0; 0.5/0.5; 0.5/1; 1/0.5; 1/1.5; 1.5/0; 1.5/0.5, dan 1.5/1 untuk masing – masing rasio kombinasi pupuk organik/anorganik). Hasil penelitian menunjukkan bahwa kombinasi pupuk organik dan anorganik memiliki pengaruh yang positif terhadap reaksi tanah (pH), P-tersedia, P-total, dan bobot segar tanaman sedap malam yang ditanam pada tanah *Typic Hapludult*. Pemberian kombinasi 50% pupuk organik dan 50% pupuk anorganik efektif meningkatkan pertumbuhan tanaman melalui peningkatan bobot segar tanaman hingga 9.240 g tanaman⁻¹ atau meningkatkan bobot segar tanaman sebesar 39% dibandingkan dengan perlakuan kontrol (tanpa pemupukan).

Kata kunci: Bobot segar, pupuk anorganik, pupuk organik, sedap malam, *Typic Hapludult*

INTRODUCTION

Ultisol is one of the soil orders that can be found in Indonesia. Ultisol covers the Java region and it is also found in Jatinangor, Sumedang, West Java. The soil in Jatinangor belongs to the Suborder *Udult*,

the Great Group *Hapludult*, and the Subgroup *Typic Hapludult*. The *Typic Hapludult* has a clay texture, acidic pH, and high amount of total-P. The structure of *Typic Hapludult* is crumbly in the topsoil but it has a clay texture in the subsoil, and the fertility status of *Typic Hapludult* is generally low because of the acidity of the soil.

Ultisol is characterized by the accumulation of clay in the soil horizon layer, which causes the less

water infiltration and increased soil erosion. *Typic Hapludult* is one of the Subgroups of Ultisol. The classification of this soil is Order *Ultisol*, Suborder *Udult*, Great Group *Hapludult*, and Subgroup *Typic Hapludult*. The name of *Typic Hapludult* consists two syllables, the first syllable shows its primary type and the second one indicates its Great Group name. *Hapludult* means the *Udult* that has another type and moisture regime (Hardjowigeno 2007).

Soil pH is an important factor that affects the amount of available-P in soil for plant uptake. In general, the amount of available-P in acid soil is low because the P is bound by Al or Fe (Hardjowigeno 2007). Most of P in soil are derived from weathering of rocks and base materials in fluoroapatite mineral ($\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2$), while the inorganic-P in acid soil is present in variscite mineral ($\text{AlPO}_4 \cdot 2\text{H}_2\text{O}$) and strengite mineral ($\text{FePO}_4 \cdot 2\text{H}_2\text{O}$), which are also the sources of available-P in soil (Santosa 2007). The main causes of low availability of P in soil for plant uptake are the low solubility of P in soil and the low P concentration at a certain time. Phosphorus in organic fertilizers can be released into soil solution after the decomposition of the organic fertilizers. In contrast, the P from inorganic fertilizers can be directly available for plant uptake.

During the decomposition of organic matter in soil, humic acid and fulvic acid are produced. Both humic acid and fulvic acid play an important role in the binding process of Al and Fe, resulting in the increase of available-P for plant uptake (Minardi and Setie 2005). Generally, nutrients are easy to be absorbed by plants in neutral pH soil, because at neutral pH most of the nutrients are mainly present in soluble form in the soil solution. In acid soil, P cannot be absorbed by plant directly because the P is bound by Al and Fe in the soil. In order to increase the plant productivity, the soil quality such as the availability of nutrients in soil must be improved. One of the materials that can be used to improve the availability of nutrients in soil is organic fertilizer. The organic fertilizer is made from natural materials such as animal manure, plant residue, garbage, or waste (Wongso 2003). Broiler chicken manure is a kind of organic materials that can be used to make an organic fertilizer. Chicken manure provides higher amounts of nutrients for plants such as N, P, K, and Ca than other organic materials such as cattle manure and goat manure. Moreover, the chicken manure is typically fast to be decomposed.

Tuberose (*Polianthes tuberosa* L.) is one of the popular ornamental plants in Indonesia. Tuberose belongs to the Family of *Amaryllidaceae* and originally comes from Mexico (South America). Tuberose has been spread and nicely adapted in tropical condition

and has a great economic value as an aromatic flowering plants for fresh cut flower and essential oil industry (Alan et al. 2007; Mazed et al. 2015). Many factors affect the growth and development of tuberose such as water availability and fertilizer application. The availability of water is a vital factor that controls the sustainable production of all agricultural crops, especially the ornamental crops (Patra et al. 2017).

Tuberose requires a good quality of growing media such as crumbly soil, good aeration, rich of organic component, and pH between 5.5 to 5.9. The recommended inorganic fertilizer dosage for tuberose is Urea (763 kg ha^{-1}), SP-36 (138 kg ha^{-1}), and KCl (83 kg ha^{-1}), meanwhile the recommended organic fertilizer dosage is 20 Mg ha^{-1} . The benefit of applying inorganic fertilizer is the fertilizer is able to provide nutrients immediately for plants, but it can cause a soil quality degradation for a long term application. Therefore, the use of inorganic fertilizer must be reduced. Generally, farmers apply about 20 Mg ha^{-1} organic fertilizer as a recommended dose for tuberose, but the optimum dosage of the combination of organic and inorganic fertilizers for tuberose is not known yet. Therefore, this study was conducted to find out the optimum dosage of the combination of inorganic and organic fertilizers to improve the growth of tuberose grown on *Typic Hapludult* soil.

MATERIALS AND METHODS

Study Site

The experiment was conducted in a greenhouse of Faculty of Agriculture, Universitas Padjadjaran, in Sumedang, Indonesia, which is located at 812 m above sea level.

Research Design

A Randomized Complete Block Design (RCDB) was used in this experiment with 10 treatments and three replications as follows:

- A = organic/inorganic fertilizers(0/0)
- B = organic/inorganic fertilizers(0/1)
- C = organic/inorganic fertilizers (1/0)
- D = organic/inorganic fertilizers (0.5/0.5)
- E = organic/inorganic fertilizers (0.5/1)
- F = organic/inorganic fertilizers (1/0.5)
- G = organic/inorganic fertilizers (0/1.5)
- H = organic/inorganic fertilizers (1.5/0)
- I = organic/inorganic fertilizers (1.5/0.5)
- J = organic/inorganic fertilizers (1.5/1)

The recommended dosage of organic fertilizer for tuberose is 20 Mg ha⁻¹ or 80 g polybag⁻¹. The recommended dosages for Urea, SP-36, and KCl are 763 kg ha⁻¹ or 3 g polybag⁻¹, 138 kg ha⁻¹ or 0.5 g polybag⁻¹, and 83 kg ha⁻¹ or 0.3 g polybag⁻¹, respectively.

Soil and Plant Analysis

The parameters measured in the experiment were (1) soil pH (pH meter), measured during the vegetative growth, *i.e.* 13 weeks after planting; (2) total-P (25% HCl extraction), measured at vegetative growth, *i.e.* 13 weeks after planting; (3) available-P (Bray-1 method), measured at vegetative growth, *i.e.* 13 weeks after planting; and (4) fresh weight of plant.

Statistical Analysis

Normality of the data were analyzed using Kolmogorov-Smirnov Test and then the data were analyzed using one factor Analysis of Variance (ANOVA). After that, the data were further tested using Duncan’s Multiple Range Test (DMRT) at $p < 0.05$ to compare the differences among treatments.

RESULTS AND DISCUSSION

The Effect of the Combination of Organic and Inorganic Fertilizer Application on Soil pH

The application of the combination of organic and inorganic fertilizers on *Typic Hapludult* affected the soil pH, however the effects on the soil pH were different among the treatments. The increased dosage of organic fertilizer applied showed an impact on the increase of soil pH. This effect can be found in the soil that was applied with the ratio of organic and inorganic fertilizers of 1/0 (C); 1/0.5 (F), 1.5/0 (H), 1.5/0.5 (I) and 1.5/1 (J). The application of organic fertilizer without inorganic fertilizer was able to increase the soil pH up to 5.06 (Figure 1). On the other hand, the increased dosage of inorganic fertilizer applied showed an impact on the decrease of soil pH. The results of statistical analysis showed that the addition inorganic fertilizer without organic fertilizer with the ratio of 0/1.5 resulted in the lowest soil pH (4.23) (Figure 1).

The application of organic fertilizer is effective in increasing the soil pH especially for the acidic soil. The increase of soil pH is caused by the contribution of OH⁻ ion derived from organic

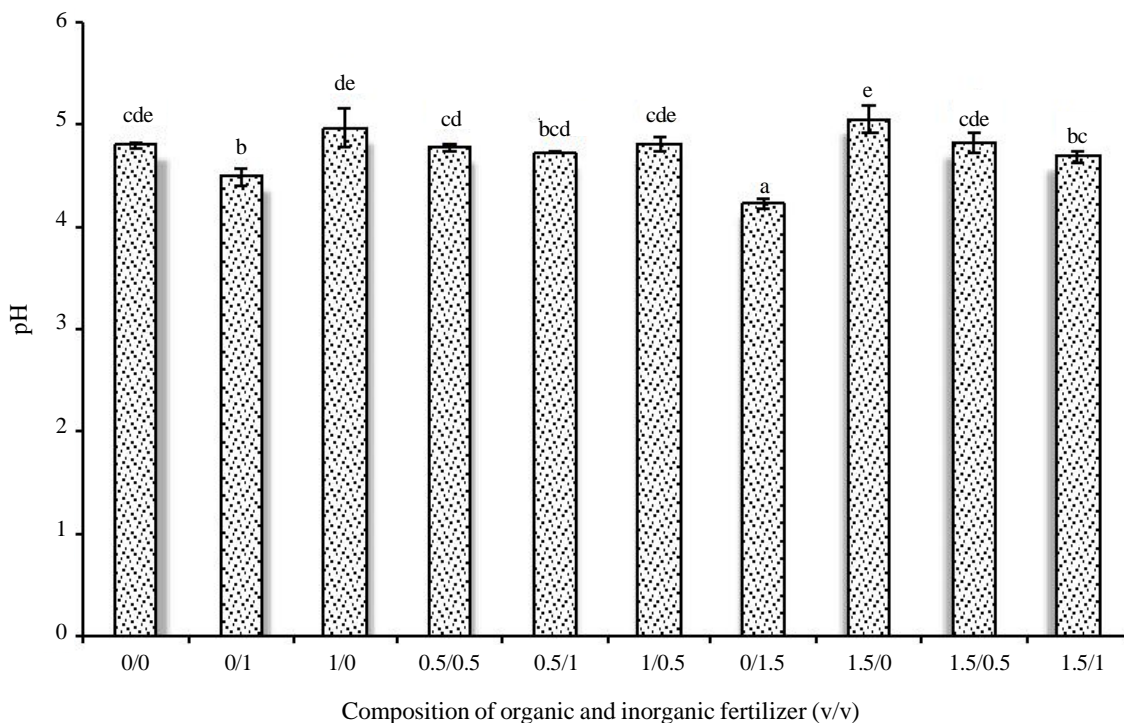


Figure 1. The effect of the combination of organic and inorganic fertilizer application on the pH of *Typic Hapludult*. The same letters above the bar chart indicate no significant difference based on DMRT at $p < 0.05$ (8.193).

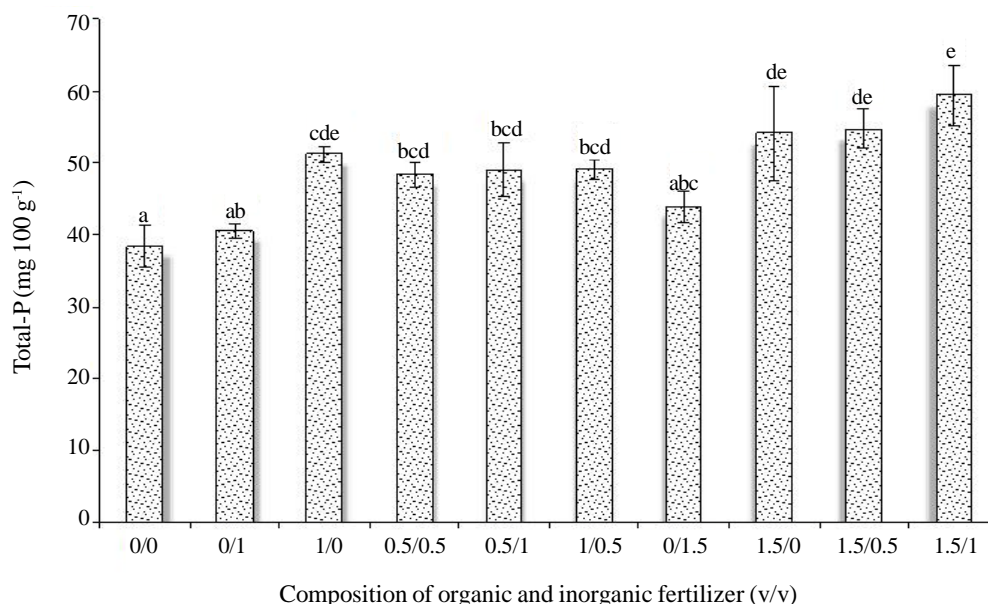
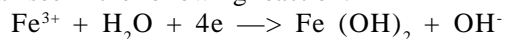


Figure 2. The effect of the combination of organic and inorganic fertilizer application on the amount of total-P in *Typic Hapludult*. The same letters above the bar chart indicate no significant difference based on DMRT at $p < 0.05$ (5.131).

fertilizer due to the reduction process (Basir 2008). Moreover, an existing Fe^{3+} will be changed into Fe^{2+} , therefore it has an opportunity to release OH^- as we can see in the following reaction:



Organic manures and microbial agents make an easy access of nutrient uptake when crop requires organic fertilizer instead of the chemical fertilizer (Vanilarasu and Balakrishnamurthy 2014). Moreover, the application of organic fertilizer prevents P-leaching. Nest *et al.* (2014) showed that the application of compost in soil increases soil organic matter content without increasing P-leaching.

The Effect of the Combination of Organic and Inorganic Fertilizer Application on the Amount of Total-P

The amount of total-P in the soil can be increased by fertilization either using organic or inorganic fertilizer. However, the organic fertilizer is more effective in increasing the amount of total-P in soil than inorganic fertilizer. The results of statistical analysis indicated that the application of organic and/or inorganic fertilizers shows an impact in increasing the amount of total-P in the soil. However, the addition organic fertilizer showed a significant effect in increasing the amount of total-P compared to the addition inorganic fertilizer (Figure 2). The application of organic and inorganic fertilizers with the ratio of 1.5/1 (J) resulted in the highest amount

of total-P in the soil ($59.37 \text{ mg } 100\text{g}^{-1}$), which is similar to that in the application of organic and inorganic fertilizers with the ratio of 1/0 (C), 1.5/0 (H) and 1.5/0.5 (I). All of these treatments resulted in the amount of total-P more than $50 \text{ mg } 100\text{g}^{-1}$. The increase of total-P in the soil applied with organic fertilizer occurs during the decomposition process of organic fertilizer, in which the organic matter produces humic and fulvic acids that can further bind Al and Fe in the soil. Therefore, P becomes available in the soil and P is dominant in organic fertilizer such as in chicken manure (Minardi and Setie, 2005; Vandecasteele *et al.* 2014).

The Effect of the Application of Organic and/or Inorganic fertilizers on the Amount of Available-P

The amount of available-P in soil is affected by soil pH, in which the soil $\text{pH} < 5.5$ will affect the availability of P, K, S, Ca, and Mg in soil. Therefore, the supply of available-P in soil can be increased by fertilization either using organic or inorganic fertilizer. The results of statistical analysis showed that the application of organic and/or inorganic fertilizers significantly increased the amount of available-P in *Typic Hapludult*. However, the application of organic fertilizer is more effective in increasing the amount of available P in the soil than inorganic fertilizer application. The amount of available-P in the soil could reach more than 1.5 mg kg^{-1} when the soil was applied with 1.5 times recommended dose

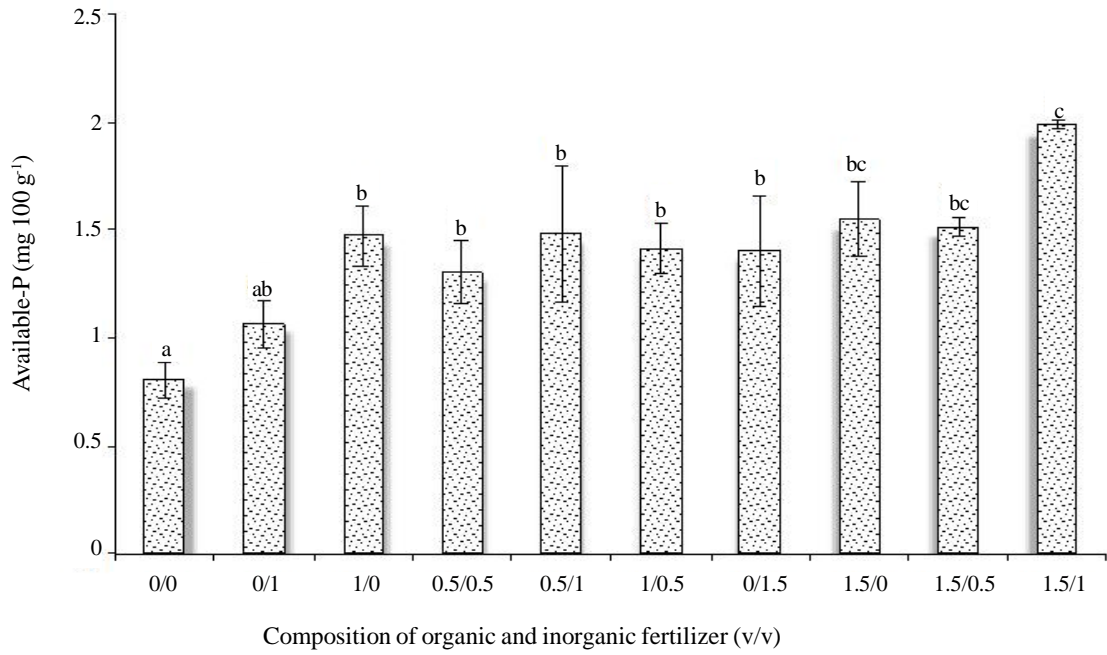


Figure 3. The effect of the combination of organic and inorganic fertilizer application on the amount of available-P in *Typic Hapludult*. The same letters above the bar chart indicate no significant difference based on DMRT at $p < 0.05$ (4.089).

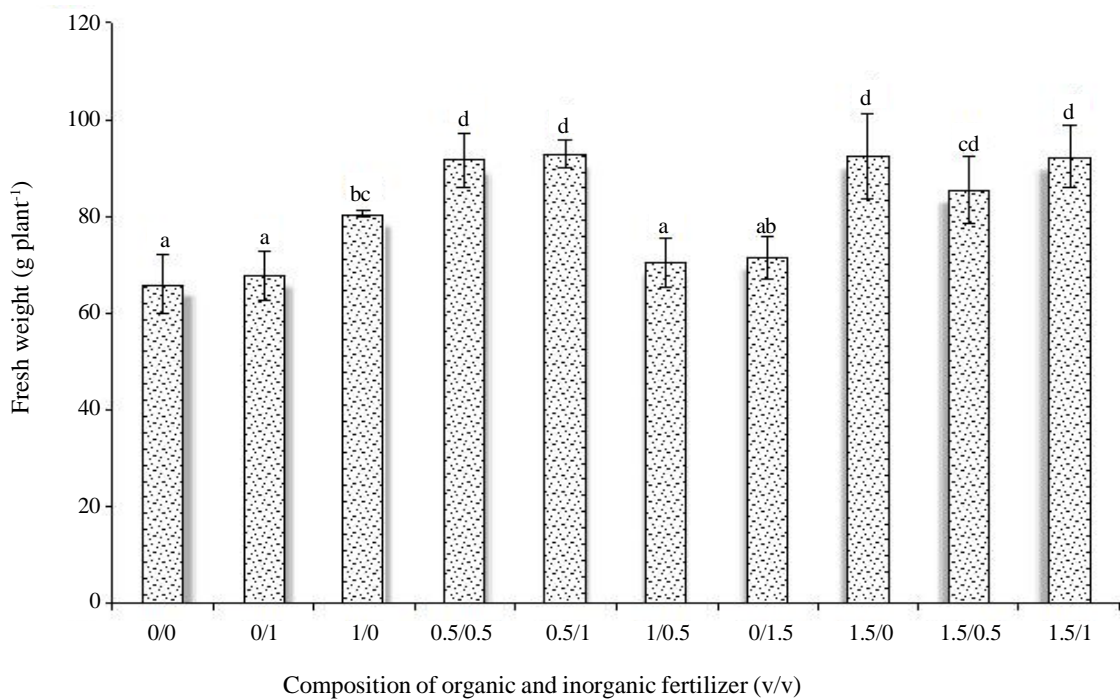


Figure 4. The effect of the combination of organic and inorganic fertilizer application on the fresh weight of tuberoses grown on *Typic Hapludult*. The same letters above the bar chart indicate no significant difference based on DMRT at $p < 0.05$ (11.828).

of organic fertilizer. The highest amount of available-P was measured in the soil applied with organic and inorganic fertilizers with the ratio of 1.5/1 (J) with the amount of available-P nearly 2 mg kg⁻¹ (1.99 mg kg⁻¹), whereas the amount of available-P in the soil without fertilizer application (control treatment) resulted in less than 1 mg kg⁻¹ (0.8 mg kg⁻¹) (Figure 3). Besides increasing the amount of available-P, other studies indicate that the application of organic fertilizer significantly improve the quality of physical soil properties and soil microbial community (Moeskops et al. 2012).

The Effect of the Combination of Organic and Inorganic Fertilizer Application on the Fresh Weight of Tuberose

Plant growth and development are affected by environmental factors, such as the availability of nutrients in soil. Soil with the low amount of nutrient content can reduce the plant growth and development, therefore increasing the amount of nutrient content in soil can improve plant growth and development, and affect the flavour quality of crops (Raffo et al. 2014). The study of Lopez-Bucio et al. (2003) showed that the ability of plants to respond appropriately to nutrient availability in soil is the fundamental factor for the adaptation of plants to environment. In this study, we investigated the impact of organic and inorganic fertilizer application on the fresh weight of tuberose grown on *Typic Hapludult*. The results of statistical analysis showed that both organic and inorganic fertilizers improved the fresh weight of tuberose. The increase of fresh weight of tuberose was correlated to the increase of plant sizes, such as the number of leaves, leaf size, plant height, etc. Our study showed that the application of organic fertilizer was more effective in improving the plant growth and development (*i.e.* increasing the fresh weight of tuberose) than inorganic fertilizer application. The plants applied with organic fertilizer and inorganic fertilizers with the ratio of 0.5/0.5, 0.5/1, 1.5/0, 1.5/0.5 and 1.5/1 resulted in the plant fresh weight more than 85 g plant⁻¹ (Figure 4). The increase of plant growth and development is an indicator of an easy process of water and nutrient uptake due to the addition of organic fertilizer (Vanilarasu and Balakrishnamurthy 2014). The study of Boraste et al. (2009) indicated that biofertilizers are used to supplement the inorganic fertilizer because of the cheaper price and a kind of renewable resources. For many crops, long term application of organic and inorganic fertilizers results in greater crop yield improvement (Yang et al. 2015).

CONCLUSIONS

The application of organic fertilizer, inorganic fertilizer or their combinations on *Typic Hapludult* shows positive effects in increasing the soil pH, the amounts of available-P and total-P, and the fresh weight of tuberose. Moreover, the organic fertilizer application is more effective in increasing the amount of available-P and total P in the soil and the fresh weight of tuberose than the inorganic fertilizer application, in which increasing the dosages of organic fertilizer and inorganic fertilizer up to 1.5 times and 1.0 times of the recommended dosage, respectively, is a good treatment.

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