Chemical Responses on Fluventic Eutrudept Due to Organic Amendments Application, in Sweetpotato (Ipomoea batatas (L.) Lam.) Farming System

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Abstract. Some organic amendments were applied to the soil samples collected from the low layer of Padjadjaran University, located at Jatinangor District, Sumedang Regency, West Java in Indonesia aimed to improve its physical, chemical and biological properties. Some responses occurred on Fluventic Eutrodepts characteristics and the yield of sweet potato. Data were obtained from the experiment of 9 treatments with 3 replications each subjected to Randomized Blocked Design. The treatments were PA (control: no treatment), PB (15 t ha^{-1} poultry manure), PC (20 t ha^{-1} poultry manure), PD (15 t ha^{-1} sheep manure), PE (20 t ha^{-1} sheep manure), PF (15 t ha^{-1} cow manure), PG (20 t ha^{-1} cow manure), PH (15 t ha^{-1} waste compost), and PI (20 t ha^{-1} waste compost). Various responses was performed on soil properties and yield of sweet potatoes. PG treatment showed the highest value on organic carbon (T-OC = 4.22%) and total-nitrogen (T-N = 0.86%); PI showed the highest value on pH (pH = 5.1), total-organic phosphorus (T-OP = 25.84 mg kg^{-1}) and yield of sweet potato (18.1 kg $plot^{-1}$); while PH showed the highest value on exchangeable potassium (E-K = 5.52 mg/100g). In fact, waste compost was recommended to applied in sweet potato farming system.

Keywords: Sweet Potato, Fluventic Eutrodepts, Organic Amendments, Soil properties, Farming System

1 Introduction

Soil behaviour is referred to the soil reactions affected by the treatments and human manipulation. Practical management of soil strictly depends on the understanding of causal relation among of soil reactions and soil manipulations. Organic amendments (OA_m) application is way of the soil manipulation methods. It is an addition of plant material or animal origin to the soil to increase its some soil properties (physical), including structures, permeability, water infiltration, water retention, aeration, and drainage. organic amendments, such as compost and humic acids, are applied to preserve top soil layer and improve organic matter in the soil. Previous studies and literatures showed organic amendments application improved soil properties i.e the soil structure, facilitated absorption of water and nutrient, decreased soil erosion and overall enhanced plant growth. Some Soil properties such as bulk density, cation exchange capacity (CEC), and available water exhibited changes due to soil composition that largely resulted from differences in composition organic matter (OM) content [1]. Furthermore, the organic amendments did not have a significant effect on biological properties as investigated by microbial biomass and respiration analysis. The chemical properties showed higher value of nitrate, available P, and concentrations of exchangeable K over 2 years as impacted of organic amendments applications [2].

In West Java Indonesia, *Ipomoea batatas* (L.) Lam., commonly known as *Ubi Cilembu* (Figure 1). *Ubi* means sweet potato, and *Cilembu* is a village in Sumedang Dystrict West Java, one of specific region where sweet potato can develope well due to the supports of specific natural resources, such as landscapes, microclimate, and soil. Its concave landscape is surrounded by hills created a specific condition on microclimate and soil properties. Sweet potatoes cultivated in Cilembu commonly called as *Ubi Cilembu*, which has specific characteristic in the taste. It has sticky liquid as honey, and it has fibrous textured on the skin. This characteristic could not be found in other region. This phenomenon exhibited a market problem in demand, especially from Japan. Therefore, in order to comply the high market demand without ignoring its quality, a diversification system to increase the productivity of *Ubi Cilembu* should be conducted.

Sweet potato included in Convolvulaceae family based on plant classification, it is a tuber vegetable which is starchy, large, and sweet tasting, the plant including of a herbaceous group, the leaves are heart-shaped and its sympetalous flowers has medium-sized [3]. The long and tapered tuberous root is edible and it has smooth skin. The growing period of sweet potato is about 3 to 4 months, due to its nutritional content and sweetness, the sweet potato is a valued commodity [4].

Sweet potato is a secondary crops which is mainly used as a source of nutrients, some minerals and vitamins mainly carbohydrates. It was considered as staple food in the future in some regions, such as in Papua, eastern of Indonesia. Indonesia is one of cultivation centers of sweet potato with many germplasms that spread in several regions. A 100 g of sweet potato has the following nutritional contents i.e. 105 kcal energy; 2.22 g proteins; 74.43% water; 14.43% starch; 3.48% total sugar; 0.58% glucose; 1.10% cellulose. Due to its nutrient content and production per unit area i.e. above 40 t/ha, it is a potential source of alternative food for developing countries with problems of nutrition [5].

Figure 1. The tuber of sweet potato, in harvesting activities at Cilembu village.

Sweet potato has an important function as a source of energy and phytochemical in human nutrition needs and animal feeding. Otherwise, it is significantly importance for medicinal and most parts of the sweet potato plant are used for traditional medicine [6]. Numerous studies showed that the leaves of sweet potato are rich in phenolic acids and anthocyanins, the content of polyphenols are radically properties, anticancer, anti diabetes, anti mutagenic activity, scavenging activity and antibacterial activity, which can be useful maintaining human health [7].

Therefore, this study conducted to observed the differences reactions of soil due to the organic amendments application. Some of the organic amendments were applied in Fluventic eutrudepts Jatinangor series in sweet potato (*Ipomoea batatas* [L.] Lam) farming system.

2 Materials and Method

2.1. Treatment

A number of 9 treatments with 3 replications subjected to Randomized Blocked Design were included. The treatments were PA (control: no treatment), PB (15 t ha-1 poultry manure), PC (20 t ha-1 poultry manure), PD (15 t ha-1 sheep manure), PE (20 t ha-1 sheep manure), PF (15 t ha-1 cow manure), PG (20 t ha-1 cow manure), PH (15 t ha-1 waste compost), and PI (20 t ha-1 waste compost) applications.

2.2. Soil Samples

Soil samples collected at field of experiment were subjected to analyses. For the field-scale samples, 27 samples were taken from the low layer of Padjadjaran University, located at Jatinangor District, Sumedang Regency, West Java, Indonesia. The area of the field examined was 0.5 ha (50 × 100 m) with an almost flat topography. The soil in this field was classified as Fluventic Eutrodept [8–10].

Soil samples were collected on May 16 (pre-application) and November 19 (post-application). To sample soils from throughout the field, the field was divided into 27 plots with an area of 2 × 4 m. In each plot, a soil sample consisted of three sub-samples was taken from the surface (< 15 cm) within a 1-m circular area from the center of the plot.

2.3 Soil Properties Analysis

The chemical properties of soil were investigated in two times: pre-planting and post-harvesting based on pH, organic-carbon (T-OC), total-nitrogen (T-N), total-organic phosphorus (T-OP), exchangeable potassium (E-K) and yield weight of the plant. Measurement of pH of soil was conducted in water and KCl solutions were determined on the natural charging discharge on soil colloids which will have a recharging effect on nutrient assessment and reaction; T-OC was analysed on soil samples by organic matter oxidizing using $K_2Cr_2O_7$ in strong sulphuric acid for 30 minutes then followed by titration of the excess of $K_2Cr_2O_7$ with ferrous-ammonium sulphate [11]; and T-N was analysed by sulphuric acid digestion using $CuSO_4$, K_2SO_4 and Se, as catalyst. Nitrogen in the digest was analysed by Kjeldahl distillation method as previously described (Bremmer and Mulvaney, 1982) while determination of T-OP and E-K were done by spectrophotometer using acetyl acetone extraction and ammonium acetate method [12]. Analyses were conducted in the Soil Laboratory, Agriculture Faculty, University of Padjadjaran, Indonesia.

2.4 Statistical Analysis

Statistical analysis using variance analysis was conducted on data obtained, followed by Fisher's LSD Analysis 5%. Descriptive statistics, correlation and regression analysis of the data were carried out using Microsoft Excel 2010 for Windows.

3 Results and Discussion

3.1 Soil pH

Figure 2 showed variable charges of soil with differences in pH H_2O and KCl < 0.5. This condition occurred due to the organic amendments application into soil [13]. In variable-charged soils, the use of organic amendments were expected to increase the pH value [14].

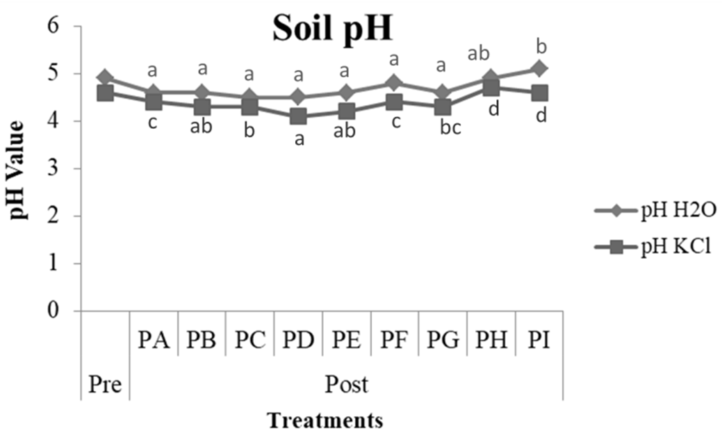

Figure 2. pH values, pre and post application; same letters represent insignificant values at 5 % level by LSD analysis.

Organic amendments is a part of organic matter (SOM) originated from animal and plant residues at various level decomposition of cells and tissues of organisms in the soil [15]. It roled in buffering process of soil pH charge. It has negative sites to absorb cation (H^+) in many acid soil (ultisols, oxisols), or release H^+ in a basic soil conversely, it push soil solution towards neutral [10]. Whether SOM changes soil pH in the long term depending on many factors [16].

In the initial process of decomposition, SOM releases anions and cations. Plant residues, especially from high nitrogen plant generally contain more anions, thus the initial process exhibit the increasing of soil pH. It could be worked to reduce the toxicity of H^+, manganese or aluminum toxicity in the rooting zone of seedling [17]. The mineralization occurred by soil microbes activities changing SOM to ammonium which increases Soil pH, and followed by nitrification process running which converted ammonium to nitrate and the process decrease soil pH.

The effect of SOM addition on soil pH depends on product of mineralization and previous soil pH (Table 1). Soil pH tend to increase due to decomposition of basic soils plants, and organic fertilizer originated from such plants, deep rooted plants that take anions from deep soil layers to the top soil surface, and plant residue high in nitrogen [18-19]. Higher residue amounts increase soil pH [20]. The content of Al-dd lead to fluctuation in pH values as impact of organic anions, directly affected on Al-dd level. Increasing of Al-dd increased negative soil surface charge due to adsorption of organic anions specifically, whereas organic anions reduced Al-dd through the formation of Al-organic anion complex under certain conditions [21]. Organic material containing specific organic anions exhibit different responses. Therefore, the use of organic materials as amendments should be compatible with the soil.

Table 1. The processes and conditions that influence whether organic matter increases or decreases soil pH [22].

Increase pH	Decrease pH
Microbial decomposition of carbohydrates	
Mineralization to ammonium	Nitrification to nitrate
Volatilization loss of ammonia gas L	Leaching loss of nitrate
High plant residue base-forming cation content	Low plant residue base-forming cation content
Large amount of residue	Small amount of residue
Soil pH < SOM pH	Soil pH > SOM pH

3.2 Organic Carbon (T-OC)

Figure 3 showed that all treatments increased organic carbon (T-OC) percentages. PG treatment exhibited the highest value (4.22%) of T-OC. In fact, animal manure contained almost 70 percent of the solid part. It consists of lignin and 50% humus [23].

It concluded that organic amendments application significantly affected on enhancement of T-OC. Previous study showed that chicken manure application enhanced T-OC from 0,66% to 1,22% due to organic matter application indirectly contribute to enhaced T-OC [24].

Generally, SOM fractions influenced soil properties both on soil physical properties and soil chemical properties such as cation exchange and nutrient cycling could be the contributing factors. However, there was a case where total soil organic carbon remains a reasonable first approximation to the functionality of SOM on soil properties. It was hypothesised that more information on the soil carbon fractions would be informative on the functionality of SOM when total soil organic carbon levels were in the range of about 0.7% to 2.0 %. For the values below 0.7%, it was likely due to insufficient SOM for maintaining functions, and for levels higher than 2.0% it was likely due to sufficient soil organic matter for maintaining most functions [25].

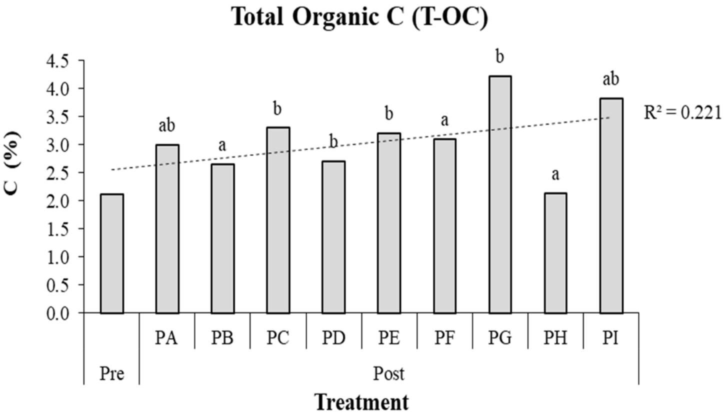

Figure 3. Organic C values (pre and post application); same letters represent insignificant values at 5 % level by LSD analysis; dotted lines show the trend of values due to OA_m Application; $R^2 = 0,221$.

3.3 Total Nitrogen (T-N)

Figure 4 showed that almost all treatments increased the total nitrogen (T-N) contents, except for the PH. The PG exhibited the highest value (0.86%). In relation to T-OC, it occurred as impact of the high amount of ingredients and high material contents in cow manure, provided that the decomposition material released nutrients and humus.

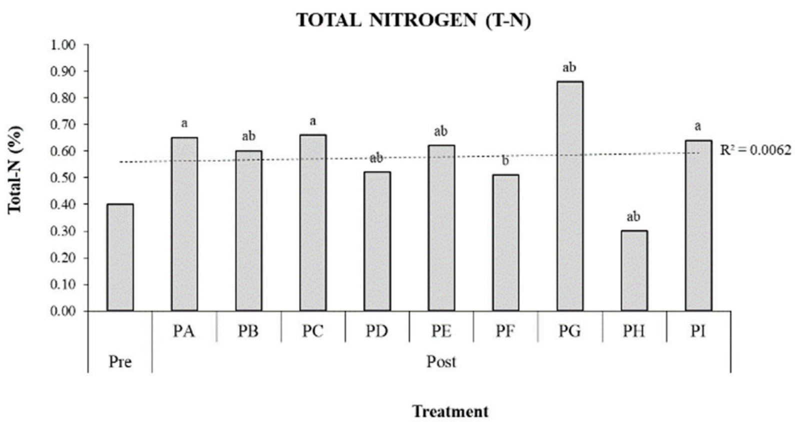

Figure 4. Total Nitrogen values (pre and post application); same letters represent insignificant values at 5 % level by LSD analysis; dotted lines show the trend of values due to OA_m Application; $R^2 = 0,0062$.

Urine and chicken manure estimated can be lost from 20 to 40% and up to 54% of the N as a result volatilization of NH_3 [26]. N element contained in the urine and the urease as urea, it is present in the chicken manure and transform the urea into NH_3 which makes it difficult to preserve the nitrogen in the animal waste; and the use of urease inhibitors has been an option to reduce the emission of ammonia and nitrous oxide [27].

3.4 Total Organic Phosphorus (T-OP)

Figure 5 showed that PA (control), PB, PE, PF, PG and PI increased organic Phosphorus (T-OP) content. PI exhibited the highest value. Organic matter application increased P availability through decomposition of organic matter. Phosphorus which bounded by Al, Fe, and Ca released into available forms for plants through the behavior of acid organic and organic chelates produced during the decomposition process [28]. Soil organic matter can degrade the capacity of P-sorption capacity in the soils [29]**.** This implied that for strong P-fixing soils, i.e. oxide-rich soils originated from volcanic ash and ferro-magnesian rocks, management systems that are adequate of collecting and preserving higher amounts of calcium-saturated soil organic matter in the top horizon increased P availability from both organic and fertilizer sources.

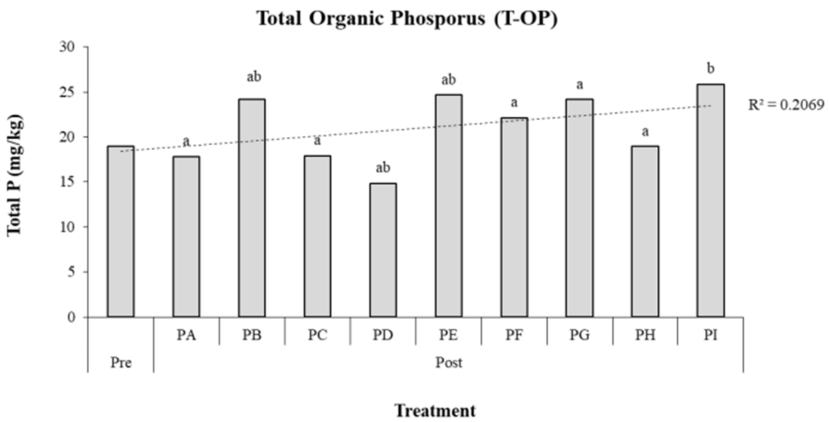

Figure 5. Total organic phosphorus in mg/Kg (pre and post application); same letters represent insignificant values at 5 % level by LSD analysis; dotted lines show the trend of values due to OA_m Application; R^2 = 0,2069.

3.5 Exchangeable Potassium (E-K)

Figure 6 showed that treatment PA (control), PB, PE, PH, and PI increased Exchangeable Potassium (E-K). PH exhibited the highest value. Exchangeable potassium (K^+) is one of cation exchange capacity agent. Soil organic matter is one of important CEC contributors in soil systems. Carboxyl and phenolic hydroxyl functional groups contribute most to the CEC of soil organic material [30–32]. The contribution of organic matter to CEC of soil has been well recognized. Its average contribution to the CEC of A horizons ranges from 14 to 56% [33]. The previous study on K adsorption by the soils suggested that organic matter might play a role in increasing the adsorption rate [34].

Generally, selectivity of the organic matter for divalent cations is higher than that for monovalent ones, unusual selectivity is displayed by certain organic compounds (e.g., valinomycin) for monovalent cations [35]. The lead-hydrogen exchange reaction in a purified humic acid system, and reported that film diffusion was the rate-measurement step [36]. The fast K exchange rate observed during the early reaction period at 298 K might be related to the behavior of organic polymers of the soil [11].

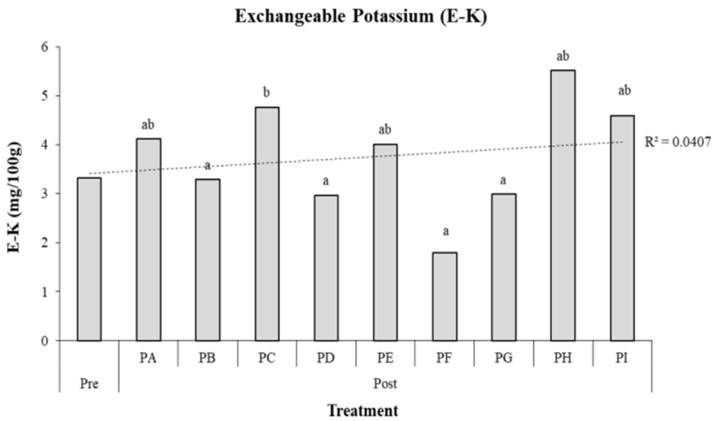

Figure 6. Exchangeable Potassium (pre and post application); same letters represent insignificant values at 5 % level by LSD analysis; dotted lines show the trend of values due to OAm Application; R2 = 0,0407.

3.6 Yield of Sweet Potato

Figure 7 showed that all treatments have no significantly differences based on statistical analysis using Duncan Test level 5%. Besides, PI treatment (20 t ha^{-1} waste compost manure exhibited the highest yield (18.1 kg $plot^{-1}$). The chemical advantages of organic matter were related to the plant nutrients cycle and the soil capability to provide sufficient nutrients for plant development and growth. Organic matter preserves plant nutrients and prevents them leaching to deeper soil horizons. Microorganisms were liable for the mineralization and immobilization of macro nutrients such as N, P and S by the organic matter decomposition [37]. Therefore, they contribute to the gradual and continuous release of important plant nutrients. Available nutrients that were not grabbed by the plants were preserved by soil organisms. In the depleted soils of organic-matter, these essential nutrients were bereaved from the system of soil profile due to leaching and runoff.

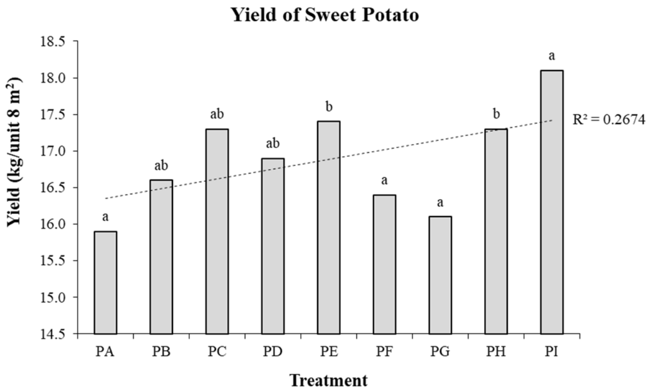

Figure 7. Yield of Sweet Potato; same letters represent insignificant values at 5 % level by LSD analysis; dotted lines show the trend of values due to OA_m Application; $R^2 = 0{,}0274$.

4 Conclusions

Various observations on soil properties and yield of sweet potatoes were found in this study due to organic amendments applications. PG treatment showed the highest value on organic carbon (T-C = 4.22%) and total-nitrogen (T-N = 0.86%); PI showed the highest value on pH (pH = 5.1), total-organic phosphorus (T-OP = 25.84 mg kg^{-1}) and yield of sweet potato (18.1 kg $plot^{-1}$); while PH showed the highest value on exchangeable potassium (E-K = 5.52 mg/100g).

It concluded that most waste compost were compatible with Fluventic eutrudept, Jatinangor series in farming system of sweet potato. In fact, waste compost consists of various kinds of organic matters such as household garbages (e.g. vegetables, fruits, and fish) and municipal waste, to mention a few. Combination of these materials enriched the waste nutrients itself. Furthermore, through the decomposition process, all the nutrients in waste compost were released into soil and tended to be available for the plant. In addition, most of available nutrients in the soil formed ions, thus stimulating the increase of pH and supporting the optimum growth of the plant.

Acknowledgments

The authors would like to thank the reviewers for valuable suggestion and comments on the manuscript, and the staff of the Laboratory of Soil Science, Padjadjaran University, for their assistance on some analysis work.

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