The Effect of Phosphate Enhanced Organic Matter on Fertility and Productivity of Latosol Soil, Bogor Regency.

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Abstract: \(P\) fertilization and application of organic matter are some of the efforts to increase the \(P\) availability in the soil. The application of organic matter enriched with phosphate fertilizer increases the \(P\)-available in soil. This study therefore aims to determine the effect of applying organic matter enriched with phosphate fertilizer on several chemical properties as well as productivity of lowland rice fields in Bogor Regency. The study was conducted by UNB's greenhouse and paddy fields in Darmaga, Kemang and Sukaraja Districts, Bogor Regency. Organic material in the form of cow dung with a dose of five levels was enriched with phosphate fertilizer in the form of \(\text{H}_3\text{PO}_4\) in an equal dose, and incubated for 30 days. Subsequently, the phosphate enriched mixture with the best incubation result for fertility level was applied in the paddy fields. The results showed about 60 tons / ha of organic matter 225ppm \(P\) of Posfat fertilizer had optimum fertility after 30 days incubation, followed by 40 tons / ha of organic, enriched with the same dose of phosphate fertilizer. In addition, Latosol soil, Bogor Regency, where organic matter enriched with about 225ppm \(P\) of phosphate fertilizer in all locations had the same soil fertility and lowland rice productivity, meaning no significant difference was obtained using the same dosage of organic matter. Meanwhile, soil fertility in the form of \(pH\), available CEC and \(P\) increased, as well as lowland rice productivity, increased with the application of organic matter (60 tons / ha).

Keywords: organic matter, fertility, and productivity.

1. Introduction

The rapid increase in human population has caused an increasing need for land, especially residential land or for industrial development, and this was the main cause of overlapping interest in land. Thus, agricultural land is turned into agricultural lands turn into industrial or residential areas, as industrial development occurs. Due to the increasing need for food, farming land must be shifted, as the expansion of the agricultural area causes new lands to be selected for possible cultivation [1].

In densely populated islands, including Java and Bali, land extensification efforts are no longer possible, and intensification is therefore one of the best alternatives. Organic and inorganic fertilizer application were an option to increase and support agricultural production. After the introduction of inorganic fertilizers as a source of nutrients quickly available to plants, farmers have tended to this option over the organic counterpart. This was possibly because organic fertilizers are difficult to obtain in large quantities and less practical, compared to the inorganic counterpart.
Latosol, Indonesia, is dominated mainly by agricultural land, and the soil has pH of 4.5-6.5, a very low organic matter content, as well as a moderate to low fertility level [2]. Phosphate (P) is largely bound to the soil in natural pH, and consequently, not readily available for plants. This study therefore aims to increase P availability in soil through the application of P fertilizers and organic matter.

Soil fertility refers to the soil’s ability to supply plants with nutrients in a balanced amount. This property is influenced by nutrient reserves, availability, size of supply, and the absence of toxic substances or substances with the ability to inhibit nutrient absorption by plants. Furthermore, the activities of various soil biological communities, including microorganisms, micro flora and soil fauna, support each other for the nutrient cycle’s sustainability, forming a biogenic soil structure[3], and this in turn regulates the soil’s physical, chemical, and biological processes. Several microbes increase plant growth and protect plant stress through the metabolism of natural growth substances, and increase nutrient and organic matter availability, and the secretion of antimicrobial compounds and pests. The ability of microbes to tether N\textsubscript{2}, dissolve the unavailable P to become available, produce natural growth substances, and change organic matter, plays a major role in increasing soil fertility.

In addition, applying organic matter to the soil improves soil structure, helps form stable aggregates, improves soil aeration, increases the amount of water retainable by soil as well as available for plants, increases nutrients, and improves soil biological properties. The application of organic matter to the soil supplies mainly nitrogen, sulfur and phosphate for plants, and also serves as a source of energy for microorganisms [4], [5].

Green manure, manure and compost are the organic matter generally applied to the soil, and the availability of these matter is influenced by the level of weathering. However, compared to green organic matter, the ripe counterpart has a bigger role in improving soil properties, as well as a smaller C/N ratio caused by decomposition.

Based on these reasons, there is a need to determine the effect of organic matter and phosphate fertilizer application. The results obtained from this study are expected to serve as a guide for improving soil properties. Therefore, this study aims to determine the effect of applying organic matter in the form of phosphate-enriched cow dung, on the fertility and productivity of Latosol soil in Bogor Regency.

2. Research Methods

The study was conducted from January to June, 2020 in agricultural lands at Darmaga, Kemang as well as Sukaraja Districts, Bogor Regency, and the research area was the rice production centre, with reddish brown Latosol soil.

2.1 Treatment and Experimental Dosages.

Organic matter (cow dung) was used in five doses, B0 (without cow dung), B1 (20 tons/ha), B2 (40 tons/ha), B3 (60 tons/ha), and B4 (80 tons/ha). Prior to application, each cow dung dosage was enriched with phosphate fertilizer (H\textsubscript{3}PO\textsubscript{4}) in five dosages, P0 (without phosphate), P1 (75 ppm), P2 (150 ppm), P3 (225 ppm), and P4 (300 ppm). Subsequently, the cow dung and phosphate fertilizer mixtures were incubated for 30 days.

Meanwhile, rice planting was carried out in Darmaga, Kemang and Sukaraja locations and organic matter was applied in the form of phosphate enriched cow dung with the best level of manure fertility. At the end of the study, a soil fertility analysis was conducted using the parameters of pH (H\textsubscript{2}O), organic C (%), Nitrogen (N) (%), P\textsubscript{2}O\textsubscript{5} Bray (ppm P), P\textsubscript{2}O\textsubscript{5} HCl 25% (mg/100 g), K exchanged (cmolc / kg), K\textsubscript{2}O HCl 25% (me/100 g), as well as CEC (me/100 g). Furthermore, the rice productivity (tons/ha) for each treatment was calculated.

The data obtained from both soil fertility and soil productivity were used to analyze differences in fertility and rice productivity in the three research locations, with the t-test statistical test [6].
3. Results and Discussion
3.1. Organic matter conditions enriched with phosphate

Generally organic matter pH decreases with increasing incubation time. The reduction in soil pH due to incubation time is believed to be caused by the decrease in acids with the ability to chelate Al and Fe produced from organic matter. Thus, Al originally chelated by the acid now reactivates in the soil solution, consequently, decreasing soil pH. Soil pH also decreases with increasing levels of phosphate application and incubation time.

Organic matter in the form of cow dung has a high C content of 28.59% and therefore increases C content in the soil. This contribution was converted into the soil amount used for this study, and 0% (B0), 0.29% (B1), 0.58% (B2), 0.87% (B3), as well as 1.16% (B4), were obtained. Thus, cow dung is a source of organic matter with the ability to increase C-organic content in the soil. This is in accordance with the report by Sanchez (1976), stating manure as a source of organic matter is able to increase organic C (between 1.42 and 3.00), N-total and exchangeable Ca (Table 1).

| Table 1. Fertility conditions of organic matter after incubation for 30 days. |
|---|---|---|---|---|---|---|---|
| No | Soil fertility and productivity | Darmaga | Kemang | Sukaraja |
|----|-----------------|--------|--------|--------|
| 1  | pH (H₂O)        | 4.1    | 4.3    | 4.5    | 4.5 | 6.0 | 5.0 | 5.2 | 6.2 |
| 2  | Nitrogen (N) (%)| 0.1    | 0.1    | 0.2    | -    | 0.1 | -   | -   | -   |
| 3  | P₂O₅, Bray (ppm P) | 0.5  | 6.1   | 27.4  | 0.7  | 6.8 | 8.7 | 1.2 | 4.8 | 19.4 |
| 4  | K₂O HCl 25% (me/100 g) | 5.0  | 8.0   | 15.0  | 6.1  | 10.4 | 16.2 | 11.2 | 6.0 | 16.0 |
| 5  | CEC (me/100 g)  | 24.3  | 24.7  | 34.7  | 22.6 | 31.5 | 48.8 | 20.3 | 24.0 | 51.9 |
| 6  | Rice Grain (tons MDG/ha) | 5.3  | 5.8   | 6.4   | 5.8  | 6.1 | 6.5 | 6.2 | 6.5 | 6.8 |

Organic matter from manure (cow dung) is able to increase total N-content in soil and this rises with increase in incubation time, as well as quantity of organic matter. The N-total of cow dung was converted to the amount of land used in this study and 0% (B0), 0.011% (B1), 0.022% (B2), 0.033% (B3), as well as 0.044% (B4), were obtained. Thus, in this study, cow dung increased the total N content in the soil from 0.13%, and this was due to the quite high N content of 1.13%.

Similarly, organic matter application is able to increase P content in the soil, and this increases with increase in the quantity of organic matter. This is possibly due to cow dung’s high alkali content with the ability to cause a rise in soil pH. Based on the analysis of cow manure, the P₂O₅ content was determined to be 3.96%, while the initial soil sample counterpart was 0.20 ppm. The cowdung’s contribution was converted based on the amount of soil used in the study, and 0 ppm (B0), 172.9 ppm (B1), 345.8 ppm (B2), 518.0 ppm (B3), as well as 691.6 ppm (B4), were obtained. Thus, in this study cow dung as a source of organic matter is able to increase available P content in soil, and 225 ppm P produced the best fertility rate of 62.7 ppm available P (Table 2).

Based on the results in Table 1 and Table 2, the best organic matter treatments for lowland rice cultivation are B0 (without organic matter), B2 (40 tons / ha), and B3 (60 tons/ha) with phosphate fertilizers, enriched with P3 (225 ppm P).
Table 2. Fertility conditions of organic matter enriched with phosphate fertilizers after incubation for 30 days.

| Treatment       | PH     | N Total (%) | P available (ppm) |
|-----------------|--------|-------------|-------------------|
| P₀ (without phosphate) | 5.50   | 0.22        | 34.7              |
| P₁ (75 ppm P)   | 5.39   | 0.21        | 42.6              |
| P₂ (150 ppm P)  | 5.46   | 0.23        | 48.2              |
| P₃ (225 ppm P)  | 5.38   | 0.23        | 62.7              |
| P₄ (300 ppm P)  | 5.37   | 0.23        | 71.0              |

3.2. Conditions of Soil Fertility and Productivity

The fertility conditions of rice planting soil administered with organic matter enriched with phosphate fertilizer were obtained by analyzing pH, Nitrogen (%), P₂O₅ Bray (ppm P), K exchanged (cmolc/kg), K₂O HCl 25% (me/100 g), and the Cat-ion Exchange Capacity / CEC (me/100 g). The results obtained were significantly different, while the different locations in this study were not significantly different. Meanwhile, soil productivity differed significantly different, as cow dung enriched with up to 60 tons/ha phosphate fertilizer led to a 0.8 tons/ha rise. Thus, the average productivity obtained was 6.6 tons of Milled Dry Grain (MDG)/ha, however, there were no significant differences in the study location.

The pH of the three low land rice research locations was acidic to slightly acidic, with Sukaraja having the highest (5.75 average), followed by Kemang and Darmaga. However, the high pH obtained in Darmaga did not influence grain weight, because the average grain weight in the three districts were the same. This is possibly the pH in the three locations is currently below the expected pH (sour to slightly acidic).

Table 3. Fertility and productivity of paddy fields with phosphate fertilizer enriched organic materials.

| No | Soil fertility and productivity | Darmaga   | Kemang   | Sukaraja |
|----|---------------------------------|-----------|----------|----------|
|    |                                 | B₀        | B₂       | B₄       | B₀ | B₂ | B₄ | B₀ | B₂ | B₄ |
| 1  | pH (H₂O)                        | 4.1       | 4.3      | 4.5      | 4.5 | 6.0 | 5.0 | 5.2 | 6.2 |
| 2  | Nitrogen (N) (%)                 | 0.1       | 0.1      | 0.2      | -   | 0.1 | -   | -   | -   |
| 3  | P₃O₅. Bray (ppm P)              | 0.5       | 6.1      | 27.4     | 0.7 | 6.8 | 8.7 | 1.2 | 4.8 | 19.4 |
| 4  | K₂O HCl 25% (me/100 g)          | 5.0       | 8.0      | 15.0     | 6.1 | 10.4 | 16.2 | 11.2 | 6.0 | 16.0 |
| 5  | CEC (me/100 g)                  | 24.3      | 24.7     | 34.7     | 22.6 | 31.5 | 48.8 | 20.3 | 24.0 | 51.9 |
| 6  | Rice Grain (tons MDG/ha)        | 5.3       | 5.8      | 6.4      | 5.8 | 6.1 | 6.5 | 6.2 | 6.5 | 6.8 |

Nitrogen (N) is an element with a role in stimulating vegetative growth, increasing the number of tillers as well as seeds or clumps, and high soil N content affects lowland rice production. In this study, the highest average soil N was found in Darmaga rice field. The application of organic matter enriched with phosphate fertilizer did not produce a significant difference in the paddy soil’s N content. The fertility level criteria for average soil N content in the three Districts are classified as very low to low fertility. Thus, N content has not been able to increase the weight of paddy rice grain by around 6.0 tons of MDG / ha, even with the potential yield of about 8.5 tons of MDG / ha.
According to Table 3, the available P content (P\(_2\)O\(_5\) Bray) of lowland rice in all test districts ranged from very low to low, while the average soil potential P (P\(_2\)O\(_5\) HCl 25%) was classified as very high. The highest available P content of 6.08ppm was obtained in Sukaraja, and this is classified as low in fertility. Thus, the organic matter was unable to increase P availability within Paddy rice soils in the three Districts, especially in Sukaraja. The potential weight of paddy rice paddy in Sukaraja is about 8.5 tons of MDG / ha, but only an average of 6.0 tons of MDG / ha is currently achieved. However, the application of organic material enriched with phosphate fertilizers was significantly different from the available P content (P2O5 Bray) and soil potential P (P\(_2\)O\(_5\) HCl 25%) of lowland rice soils, where organic matter enriched with phosphate fertilizer increased the available P content and soil potential P.

From the results of the research in Table 3, the K\(_2\)O levels (HCl 25% me / 100 g) of lowland rice soil ranged from 9.3 - 11.1 me/100 g, and were consequently classified as very low to moderate, in all districts. Thus, the application of organic matter enriched with phosphate fertilizers produced significantly different K\(_2\)O content (HCl 25% me / 100 g) in lowland rice soil, where organic matter enriched with phosphate fertilizer increased K\(_2\)O content (HCl 25% me / 100 g) in rice fields.

Furthermore, the Cat-ion Exchange Capacity (CEC) of lowland rice farm was between 27.9 and 35.4 me/100g, and consequently, classified as very low to moderate in all districts. Thus, the application of organic matter enriched with phosphate fertilizers produced significant difference in the CEC content (me / 100 g) of lowland rice soil, where phosphate enriched organic matter increased the CEC content (me / 100 g) of lowland rice soil (25.7 - 45, 1 me / 100 g).

4. Conclusion

Based on this research, the fertility rate produced by 60 tons/ha of organic matter enriched with about 225 ppm P of Phosphate fertilizer and incubated for 30 days, was the best, followed by 40 tons/ha of organic matter enriched the same dose of phosphate fertilizer. These two treatments are therefore suitable for lowland rice cultivation. Bogor Regency Latosol administered with organic material enriched with about 225ppm of phosphate fertilizer as much as 225 ppm P, produced the same level of soil fertility and lowland rice productivity in all the study locations, meaning no significant difference was obtained using the same dosage of organic matter. Meanwhile, soil fertility in the form of Ph, available CEC and P, as well as lowland rice productivity increased with the application of organic matter (60 tons / ha).

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