Effect of plant spacing and type of P fertilizer on soil chemical properties and yield of maize on C type swampland South Kalimantan

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Abstract. Tidal swampland is one of the suboptimal lands need technology to increase the yield of maize crops and soil quality. This study aimed to determine the effect of plant spacing and types of P fertilizer on the chemical properties of soil and maize yields, was carried out in type C tidal swampland, and arranged in factorial Randomized Completely Block Design (RCBD). The first factor was the plant spacing, consisting of legowo and zigzag planting system. The second factor was the application of P fertilizer types, namely 1000 kg ha\(^{-1}\) RPR, 250 kg ha\(^{-1}\) SP-36, 1000 kg ha\(^{-1}\) Guano Phosphate, and without P. The results showed that the treatments of P fertilizer type could increase the pH value and available P-nutrient content. Total N content at legowo plant spacing was higher than at zigzag spacing. The highest available K content in all treatments was at 60 days after planting. The zigzag spacing is significant in increasing maize yield by 30% compared to legowo spacing. The provision of RPR fertilizer increased maize yield significantly up to 20%. Therefore, the zigzag spacing and the provision of RPR fertilizer are recommended for maize cultivation in type C tidal swamplands.

1. Introduction

Maize is one of the strategic cereal commodities that have economic values and have the opportunity to be developed. According to the Ministry of Agriculture [10], national productivity of maize is low, reaching 4.5 - 5 tons ha\(^{-1}\). The low national maize productivity is due to the inability of farmers to apply the appropriate maize cultivation techniques according to different types of land. High demand on food crops due to population pressure increased the use of marginal (suboptimal) lands. One effort to increase maize productivity is to cultivate maize in one of the suboptimal lands, namely tidal swampland.

In Indonesia, there are many suboptimal lands in the form of tidal swampland. Based on the results of spatial calculations using land maps, review, the swamp area in Indonesia is ± 33.42 million ha or 18.28% of the total land area of Indonesia. Of this area, around 19.99 million ha is potential land to be developed into agricultural land. Tidal swampland has low soil fertility, acidic soil reactions, pyrite presence, high levels of Al, Fe, Mn, and organic acids, P deficiency, poor alkaline cation such as Ca, K, Mg, and depressed microbial activity (Arsyad et al.) [2].

Cultivation of maize in tidal swampland can be done by modifying cultivation techniques. According to Neonbeni [12] the level of plant density shows the number of plant populations on cropping land. High populations do not certainly produce maximum yields, because there are influences of environment and cultivars characteristics. So, it is necessary to manage the appropriate plant spacing so that the plants can produce maximum yields. Meanwhile, according to the results of the study of Husnain et al. [7] in Pelaihari, Tanah Laut Regency, South Kalimantan Province, maize productivity with the application of Moroccan RPR showed an average yield above 12 tons/ha. These results are higher than Tunisia RPR, Senegal RPR, and Jordan RPR. Based on these results, the Moroccan RPR can be recommended for food crops in acid soils. Other researchers also reported that the use of natural...
phosphate was attractive to farmers due to its lower price compared to P fertilizer processed in the factory. Besides, natural phosphate can provide P as well as having a residual effect so that it can function as a slow-release fertilizer (Ahn) [1].

In this study, a modification of the plant spacing and the application of various types of phosphate fertilizer were carried out which was expected to prove that the chemical properties of soil and yield of maize in tidal swampland can be improved. This study aimed to determine the effect of plant spacing and type of phosphate fertilizer on the chemical properties of soil and maize yields and to know the appropriate combination of plant spacing and phosphate fertilizer type to improve soil chemical properties and yields of maize in type C tidal swampland.

2. Materials and Method

This research was carried out through two stages, namely field observations and laboratory analysis. Observations in the field were carried out at the Balittra Experimental Field in Simpang Jaya Village, Wanaraya District, Barito Kuala Regency, South Kalimantan Province. Meanwhile, laboratory analysis activities were carried out at the Balittra Experimental Laboratory, Banjarbaru City, South Kalimantan Province. The study was conducted from November 2018 to February 2019.

2.1. Materials

The corn cultivar used in this study was a hybrid corn cultivar (Pioneer 36). The experimental field was given 5 tons ha\(^{-1}\) manure, 1 ton ha\(^{-1}\) dolomite, 450 kg ha\(^{-1}\) urea, and 100 kg ha\(^{-1}\) KCL. Each treatment was made 3 replications as blocks. Thus, there were 24 treatment plots with a size of 5m x 4m.

2.2. Method

The research was arranged in factorial Randomized Completely Block Design (RCBD) with two factors. The first factor was plant spacing, consisting of jajar legowo with a spacing of 90cm x 50cm x 20cm (A1) and zigzag with a spacing of 75cm x 25cm x 25cm (A2). The second factor was the type of phosphate fertilizer, consisting of 1 ton ha\(^{-1}\) Morocco Reactive Phosphate Rock (B1), 250 kg ha\(^{-1}\) SP-36 (B2), 1 ton ha\(^{-1}\) guano phosphate (B3), and without P fertilizer (B4).

The variables observed in this study were soil chemical properties and yields of maize plants. The parameters of soil chemical properties observed included pH \(H_2O\) and pH KCl which were measured using the Tester 35 series, soil organic C content measured with Walkley & Black method, available-K measured with NH\(_4\)OAc 1 N method, available P measured with Bray-I method, and total N-method by the Kjeldahl method. Observation of soil chemical properties was carried out at 0, 30, 60, and 90 days after planting. Parameters of maize crop yield observed included ear diameter, ear length, number of seeds per ear, P uptake of the shelled, dry weight of 100 seeds, shelled, cob, and stover, and productivity. Data were analyzed with variance analysis (ANOVA) and tested further with HSD with a confidence level of 95% and a significant level of \(\alpha = 5\%\) using R software.

3. Results

A. Initial Soil Properties

Swampland is a land that is always overfilled with water throughout the year or inundated with shallow water (SSSA) [15]. Based on tidal influences, swampland can be divided into 3 zones, namely: saltwater/brackish tidal swamps (type A and B), freshwater tidal swamps (types A, B, C, and D), and non-tidal swamps (Subagyo) [16].

Table 1 presents the initial chemical properties of soil in type C tidal swampland in Simpang Jaya Village, Wanaraya District, Barito Kuala Regency, South Kalimantan Province. The results of soil analysis show that the soil of the study area has very acidic pH values and high organic C content. Meanwhile, macronutrient content such as total N is classified as moderate, Kdd is classified as medium, and available P content is classified as moderate. This shows that the land has problems with very low pH.
values. According to Riwandi et al. [14], the optimal level of soil acidity (pH) for the growth and development of maize plants ranged from 5.6 – 6.2. According to Susilawati et al. [17], tidal swampland has several problems in terms of soil fertility, such as soil pH and low nutrient content, high Fe and aluminum content, and stagnant water that often cannot be controlled.

Table 1. Initial chemical properties of the soil in type C tidal swampland

| Chemical properties | Unit     | Value  | Category* |
|---------------------|----------|--------|-----------|
| pH H2O              |          | 3.94   | Very acidic |
| pH KCl              |          | 3.25   | Very acidic |
| Organic C           | %        | 3.421  | High      |
| Total N             | %        | 0.387  | Medium    |
| Kdd                 | cmol kg\(^{-1}\) | 0.422 | Medium    |
| Available P         | ppm      | 3.75   | Medium    |

*aCategory is based on Balai Penelitian Tanah

B. pH and organic C content of type C tidal swampland after being treated with different spacing and type of phosphate fertilizer

According to Hakim et al. [5] the content of organic matter in the soil is influenced by soil depth, soil texture, climate, soil acidity, drainage conditions, and age of vegetation. Meanwhile, soil acidity (pH) affects plant growth directly and indirectly.

Table 2. pH and organic C content of the soil

| Treatment                      | Soil pH  | Organic C (%) |
|--------------------------------|----------|---------------|
|                                | 30 dap   | 60 dap        | 90 dap        | 30 dap | 60 dap | 90 dap |
|                                | H2O      | KCl           | H2O           | KCl     | H2O    | KCl     |
| Plant spacing                  |          |               |               |         |        |         |
| Legowo                         | 4.04 a   | 3.43 a        | 3.86 a        | 3.33 a  | 4.27 a | 3.43 a  | 3.42 a | 4.02 a | 4.01 a |
| Zig - Zag                      | 4.10 a   | 3.41 a        | 3.92 a        | 3.41 a  | 4.27 a | 3.50 a  | 3.87 a | 4.09 a | 3.68 a |
| Type of phosphate fertilizer   |          |               |               |         |        |         |
| Morocco RPR                    | 4.09 p   | 3.40 p        | 3.99 p        | 3.37 p  | 4.37 p | 3.56 p  | 3.41 p | 3.96 p | 3.95 p |
| SP-36                          | 4.05 p   | 3.44 p        | 3.82 p        | 3.32 p  | 4.23 p | 3.44 p  | 3.84 p | 4.30 p | 3.71 p |
| Guano phosphate                | 4.03 p   | 3.42 p        | 3.78 q        | 3.33 p  | 4.21 p | 3.45 p  | 3.72 p | 3.81 p | 3.74 p |
| Without P                      | 4.11 p   | 3.44 p        | 3.98 p        | 3.45 p  | 4.27 p | 3.42 p  | 3.63 p | 4.15 p | 3.99 p |
| Interaction                    | (-)      | (-)           | (-)           | (-)     | (-)    | (-)     | (-)    | (-)    | (-)    |
| CV (%)                         | 2.86     | 2.53          | 2.82          | 3.93    | 2.57   | 3.51    | 17.10  | 8.02   | 20.4    |

Remarks: Values followed by the same letters in the same column are not significantly different according to Tukey Honestly Significant Difference (HSD) test at 5%.

The analysis results of pH and organic C content presented in table 2 inform that there is no interaction effect between spacing and type of phosphate fertilizer. The pH value at 60 days after planting shows a higher value compared to the pH value at 30 and 90 days after planting. This shows that there is an increase in pH value due to the administration of 1 ton ha\(^{-1}\) dolomite. According to Syahputra et al.
[18], the application of dolomite lime can increase the pH value of soil in the soil with acidic reactions. This increase is due to the presence of hydroxyl ions which bind acidic cations (H and Al) to soil colloids to be inactive, so that pH increases.

There was a significant difference in soil pH value at 30 days after planting in the variable of pH H2O between the types of phosphate fertilizer, where Morocco RPR fertilizer showed the highest yield, while Guano Phosphate showed the lowest yield. This is thought to be related to the condition of microorganisms at 60 days after planting because microorganisms can increase or decrease soil pH. Under these conditions, microbial living conditions are no longer supportive because macronutrients as nutrients to support life are no longer available (Maa'shum et al.) [11]. Table 2 shows that there is no significant effect of the two treatments on organic C content. The spacing and type of phosphate fertilizer do not affect the organic C content of the soil. This is in accordance with the results of Judge et al. (1986) stating that the content of organic matter in the soil is influenced by soil depth, soil texture, climate, soil acidity, drainage conditions, and age of vegetation.

### C. The macronutrient content of N, P and K in type C tidal swampland after treated with different spacings and types of phosphate fertilizer

Table 3 shows that total N, available P, and available K content are not influenced by the interaction between plant spacing and type of phosphate fertilizer. Total N content at 30, 60, and 90 days after planting are not significantly affected by the two factors. This is presumably because the maize cultivars used are the same, so they have the same ability to absorb nutrients especially N. Besides, it can be caused by the initial soil properties and the same nitrogen availability.

#### Table 3. Content of total N, available P, and available K

| Treatment               | Total N (%)      | Available P (%) | Available K (cmol kg⁻¹) |
|-------------------------|------------------|-----------------|-------------------------|
|                         | 30 dap | 60 dap | 90 dap | 30 dap | 60 dap | 90 dap | 30 dap | 60 dap | 90 dap |
| Legowo                  | 0,36 a  | 0,37 a  | 0,37 a  | 27,43 a | 30,35 a | 32,72 a | 0,21 a  | 0,36 a  | 0,25 a  |
| Zig - Zag               | 0,37 a  | 0,34 a  | 0,36 a  | 29,97 a | 29,58 a | 47,46 a | 0,18 b  | 0,30 a  | 0,24 a  |
| **Plant spacing**       |        |        |        |        |        |        |        |        |        |
| Morocco RPR             | 0,35 p  | 0,36 p  | 0,38 p  | 25,99 p | 26,75 p | 51,42 p | 0,19 p  | 0,33 p  | 0,25 p  |
| SP-36                   | 0,36 p  | 0,35 p  | 0,36 p  | 30,24 p | 39,04 p | 41,48 p | 0,17 p  | 0,32 p  | 0,24 p  |
| Guano phosphate         | 0,36 p  | 0,35 p  | 0,37 p  | 25,88 p | 30,63 p | 35,55 p | 0,21 p  | 0,31 p  | 0,28 p  |
| Without P               | 0,37 p  | 0,36 p  | 0,36 p  | 32,70 p | 33,43 p | 31,94 p | 0,19 p  | 0,36 p  | 0,22 p  |
| Interaction (-)         | (-)    | (-)    | (-)    | (-)    | (-)    | (-)    | (-)    | (-)    | (-)    |
| CV (%)                  | 7,93    | 6,01    | 4,31    | 33,57    | 30,84    | 53,19    | 14,12    | 23,23    | 23,32    |

Remarks: Values followed by the same letters in the same column are not significantly different according to Tukey Honestly Significant Difference (HSD) test at 5%.

*a dap: days after planting

The available P content in the soil at 30, 60, and 90 days after planting is not significantly affected by the spacing and type of phosphate fertilizer. Table 3 shows that there is a significant increase in
available P content in the soil treated with Morocco RPR from 30 to 90 days after planting. This proves that the natural phosphate element in the Morocco RPR remains in large quantities after the end of the growing season. Natural phosphate is insoluble in water but dissolves in acidic conditions. The P nutrient in natural phosphate is slow (slow-release). For natural phosphate to be an effective fertilizer, natural phosphate must be reactive so that it is easily dissolved in the soil. The land must be wet so that diffusion of hydrogen and phosphate ions and calcium ions can be available to plants (Kasno et al.) [9].

The available K content at 30 days after planting is significantly affected by the plant spacing factor, where the available K content of the soil treated with legowo spacing shows a higher value than the soil treated with zigzag spacing. This is presumably due to differences in available K nutrients in the initial soil conditions. According to Winarso [20], the factors that influence potassium uptake in the soil are soil parent material, topography, drainage, soil depth (solum), K concentration, CEC, soil temperature, and soil water content.

D. The ear diameter, the ear length, and the number of seeds after treated with different spacings and types of phosphate fertilizer

Table 4 shows that ear diameter, ear length and the number of seeds are not significantly affected by the interaction between plant spacing and types of phosphate fertilizer. The spacing treatment alone significantly affected the ear diameter, where the zigzag spacing showed a higher value. This is allegedly due to the denser density of the zigzag spacing compared to the legowo spacing. The ear length and the number of seeds is not significantly affected by the two factors. This is presumably because the need for P elements in the ear has been fulfilled with the nutrients provided.

Table 4. Ear diameter, ear length, and number of seeds

| Treatment                | Ear diameter (cm) | Ear length (cm) | Number of seeds |
|--------------------------|-------------------|-----------------|-----------------|
| Plant spacing            |                   |                 |                 |
| Legowo                   | 4.24 a            | 20.29 a         | 553.56 a        |
| Zig - Zag                | 3.97 b            | 19.81 a         | 515.88 a        |
| Type of phosphate fertilizer |               |                 |                 |
| Morocco RPR              | 4.27 p            | 20.63 p         | 563.56 p        |
| SP-36                    | 3.99 p            | 19.58 p         | 520.16 p        |
| Guano phosphate          | 4.19 p            | 30.80 p         | 556.40 p        |
| Without P                | 3.97 p            | 19.20 p         | 498.76 p        |
| Interaction              | (-)               | (-)             | (-)             |
| CV (%)                   | 14.52             | 14.44           | 27.49           |

Remarks: Values followed by the same letters in the same column are not significantly different according to Tukey Honestly Significant Difference (HSD) test at 5%.

E. The dry weight of shelled, 100 seeds, and cobs after treated with different plant spacings and types of phosphate fertilizer

The observation results on the dry weight of shelled, 100 seeds, and cob in Table 5 show there is no interaction effect between the two factors. The treatment of spacing and type of phosphate fertilizer did not show significant effects on the dry weight of shelled, 100 seeds, and cob. This proves that maize planted with zigzag spacing with higher density can produce the same assimilation as the maize planted legowo spacing. According to Rahni [13], the increase in seed dry weight is closely related to the magnitude of photosynthate translocation into seeds. Increasing the dry weight of seeds also indicates the
better root plant system to absorb nutrients from the soil. Photosynthate translocation to the reproductive organs causes the formation of cobs and the filling of seeds to take place well then larger seeds are formed.

Table 5. Dry weight of shelled, 100 seeds, and cob

| Treatment                          | Dry weight of shelled (gram) | Dry weight of 100 seeds (gram) | Dry weight of cob (gram) |
|------------------------------------|------------------------------|--------------------------------|--------------------------|
| Plant spacing                      |                              |                                |                          |
| Legowo                             | 131.40 a                     | 25.25 a                        | 21.50 a                  |
| Zig - Zag                          | 119.04 a                     | 24.48 a                        | 18.90 a                  |
| Type of phosphate fertilizer       |                              |                                |                          |
| Morocco RPR                        | 136.51 p                     | 25.53 p                        | 21.61 p                  |
| SP-36                              | 123.97 p                     | 24.74 p                        | 19.91 p                  |
| Guano phosphate                    | 125.76 p                     | 24.64 p                        | 21.20 p                  |
| Without P                          | 114.63 p                     | 24.55 p                        | 18.26 p                  |
| Interaction                        | (-)                          | (-)                            | (-)                      |
| CV (%)                             | 15.19                        | 8.13                           | 14.37                    |

Remarks: Values followed by the same letters in the same column are not significantly different according to Tukey Honestly Significant Difference (HSD) test at 5%.

F. P uptake of the shelled maize after treated with different spacings and types of phosphate fertilizer

Figure 1 is a histogram of P uptake of the shelled, which explains that the highest P uptake was found in a combination of legowo spacing treatment and Morocco RPR fertilizer. Meanwhile, the lowest P uptake was found in a combination of zigzag spacing and without phosphate fertilizer. Legowo spacing showed a higher P uptake compared to zigzag spacing. This is presumably because the plants with legowo spacing are easier to obtain P nutrients due to the wider distance between roots. Meanwhile, the Morocco RPR treatment showed the highest P uptake because the phosphorus content in Morocco RPR fertilizer
(46%) is higher compared to phosphorus content in SP-36 (36%) and guano phosphate fertilizer (16%). According to Hakim [4], P uptake depends on root contact with P in the soil solution. Distribution of roots in the soil plays an important role in increasing P uptake and dry weight of plants. Besides, the absorption of P by the roots of maize plants is influenced by the nature of the roots and the nature of the soil in providing P. The result of this study are in line with the conclusions of Husnain et al. [7].

G. Productivity and dry weight of stover after treated with different spacings and types of phosphate fertilizer

Productivity and dry weight of stover is one of the important parameters in knowing the quantity of maize yield. The value of productivity was derived from the conversion of the results of the tile plot. Table 6 shows the productivity and dry weight of stover. The treatment of phosphate fertilizer did not show a significant effect on the two variables. This is presumably because the needs of the element P have been fulfilled. Although there was no significant difference, the Morocco RPR fertilizer showed the highest values of productivity and dry weight of stover.

Table 6. Productivity and dry weight of stover

| Treatment | Productivity (ton ha⁻¹) | Dry weight of stover (kg) |
|-----------|-------------------------|--------------------------|
| Plant spacing |                         |                          |
| Legowo    | 17.55 b                 | 13.51 b                  |
| Zig - Zag | 20.26 a                 | 15.61 a                  |
| Type of phosphate fertilizer |                  |                          |
| Morocco RPR | 19.75 p                 | 15.63 p                  |
| SP-36     | 18.22 p                 | 14.26 p                  |
| Guano phosphate | 18.70 p                 | 14.10 p                  |
| Without P | 18.96 p                 | 14.24 p                  |
| Interaction | (-) | (⁺) |                          |
| CV (%)    | 8.18                    | 12.03                    |

Remarks: Values followed by the same letters in the same column are not significantly different according to Tukey Honestly Significant Difference (HSD) test at 5%.

Meanwhile, the treatment of spacing showed a significant effect on crop productivity. Treatment of zigzag spacing showed a higher yield compared to legowo spacing. This shows that maize plants with denser density, zigzag spacing, can produce higher yield. Increased productivity is also influenced by more plant populations at zigzag spacing. Herlina [6], states that wide spacing is considered not very efficient in land use. Jafri's research [8] shows that zigzag spacing can increase the productivity of maize plants.

Plant spacing treatment showed a significant effect on plant dry weight, where the dry weight of plant stover with zigzag spacing was higher than the dry weight of plant stover with legowo spacing. This is inversely proportional to Fadilah and Akbar's research [3] that wider spacing results in better root growth and no competition for sunlight or nutrients. Table 6 proves that at a zigzag spacing that is denser than the legowo spacing, there is no competition for roots on nutrients and absorption of sunlight by leaves. This is because the nutrients provided are sufficient, and the position of leaves between plants does not cover each other so that there is no competition for sunlight. This means applying phosphate rock combined with manure could improve maize yield on swampland soil (Table 6) significantly. Similar
result was reported by Waigwa et al. [19], showing that combining phosphate rock with the organic materials improved its relative agronomic effectiveness for maize.

Conclusion
A combination of zigzag spacing and Moroccan RPR fertilizer application can improve chemical properties of the soil of type C tidal swampland with a limiting factor of high soil acidity, and can produce optimal maize yields cultivated on it. The zigzag planting increased the yield of maize by 30% higher than the legowo. The application of Morocco RPR fertilizer increased maize yield significantly up to 20% and showed the highest available P residue of up to 60% compared to other types of phosphate fertilizers. Therefore, the zigzag spacing and application of Morocco RPR fertilizer are recommended for maize cultivation on type C tidal swamplands.

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REFERENCES

[1] Ahn, P M 1993 Tropical Soils and Fertilizer Use. Longman. UK.
[2] Arsyad, D M, B B Saidi and Enrizal 2014 The development of agricultural innovations in tidal swamps supports food sovereignty. Center for Assessment and Development of Agricultural Technology. Jambi
[3] Fadilah and K Akbar 2015 Effect of phosphate fertilizer application and appropriate planting distance on the growth and yield of sweet corn plants Research Journal 2 (2): 71-81
[4] Hakim, N 2005 Management of Soil Fertility with Integrated Liming Technology Andalas University Press, Padang
[5] Hakim, N, M Y Nyakpa, A M Lubis, S G Nugroho, M A Dika, G B Hong, dan H H Bailey 1986 Lecture in Soil Science SPTN / USAID Soil Science Cooperation Agency (University of Kentucky)
[6] Herlina, 2011 Study of Variation of Planting Distance and Time of Planting Sweet Corn in the Intercropping System of Sweet Corn and Peanut. Padang: Andalas University Postgraduate Program.
[7] Husnain, S Rochayati, T Sutriadi , A Nassir, and M Sarwani 2014 Improvement of soil fertility and crop production through direct application of phosphate rock on maize in Indonesia. Procedia Engineering 83:336 – 343.
[8] Jafri 2011 Response of the growth of some maize varieties to the straight and zigzag planting systems in West Kalimantan peatlands Cereals National Seminar 2011. West Kalimantan Agricultural Technology Study Center.
[9] Kasno, A, S Rochayati, dan B H Prasetyo 2011 Deposits of Deposits and Characteristics of Natural Phosphates <http://balittanah.litbang.deptan.go.id>.
[10] Ministry of Agriculture 2015 The Ministry of Agriculture's Strategic Plan for 2015-2019 Ministry of Agriculture
[11] Maa’shum, M, J Soedarsono, dan L E Susiowati 2003 Soil Biology CPIU Post IAEUP Bagpro Improvement of Human Resources Directorate General of Higher Education Ministry of National Education Jakarta
[12] Neonbeni, Y 2010 Effect of Plant Populations and Varieties on Seed Results, Production, and Quality of Local Maize in Dry Land. Denpasar: Udayana University.
[13] Rahni, N M 2012 Effect of PGPR fitohormon on growth of maize (Zea mays). Journal of Agribusiness and Regional Development Vol 3 (2): 27-35
[14] Riwandi, M Handajaningsih, and Hasanudin 2009 Corn Cultivation Techniques with Organic Systems in Marginal Land. Bengkulu: UNIB press
[15] SSSA (Soil Science Society of America) 1984 Glossary of Soil Science Terms. Madison, Wisconsin, USA
[16] Subagyo, H 1997 Potential development and spatial development of swamps for agriculture p 17-55 in the U.S. Karama et al. (editor). Prosidium of the National Symposium and VI PERAGI Congress. Main Paper. Jakarta, 25-27 June 1996
[17] Susilawati, A, D Nursyamsi, and M Syakir 2016 Optimizing the use of tidal swamps to support national food self-sufficiency. Journal of Land Resources 10 (1): 51-64
[18] Syahputra, D, M R Alibasyah, and T Arabia 2014 Effect of compost and dolomite on some chemical properties of ultisol and soybean (Glycine max L Merril) yields on terraced land. Journal of Land Resource Management 4 (1): 535-542
[19] Waigwa M W, C O Othieno, J R Okalebo 2003 Phosphorus Availability as Affected by the Application of Phosphate Rock Combined with Organic Materials to Acid Soils In Western Kenya, Expl Agric 39: 395–407
[20] Winarso, S 2005 Soil Fertility Gava Media. Yogyakarta.