Effect of P fertilizer formula to the growth and yield of sweet corn on peatland

J Purnomo and I G M Subiksa

Indonesian Soil Research Institute, Bogor, Indonesia

E-mail: purnomo0204@gmail.com

Abstract. Indonesia has 14.93 million ha of peatlands spread across Sumatra, Kalimantan and Papua. Peatlands productivity is very low due to its characteristics that do not support optimal plant growth. The research objective was to assess the effect of P fertilizer application on peatlands to sweet corn yield and determine the dosage. This research has been carried out on drained peat lands in Rasau Jaya, Kubu Raya Regency in West Kalimantan. The research used a randomized complete block design with nine treatments namely Control, NK, NPK, NPK+Mg, ¾ NK+700 kg P fertilizer ha⁻¹ and four rates of P fertilizer were 350, 700, 1,050 and 1,400 kg ha⁻¹. The results showed that the P fertilizer application has significantly affect plant growth, ear length, ear diameter, biomass and yield of fresh sweet corn ear. The application of NK+700 kg P fertilizer ha⁻¹ produce higher biomass by 77% and 47% compared to NPK+Mg treatment and NK treatment respectively. The application of 700 kg P fertilizer ha⁻¹ also significantly increased fresh ears by 51% and 43% compared to NPK+Mg treatment and NK treatment respectively. The optimum rate of P fertilizer for sweet corn on peatlands is 670 to 890 kg ha⁻¹.

1. Introduction
Indonesia has peat lands resources covering an area of 14.93 million ha [1] and makes Indonesia a country that has the largest peat lands in the world. The distribution of peatlands is found in Sumatra, Kalimantan and Papua. Most of the peatlands are located in the tidal and swampy zone and a small part is in the form of upland peat. Most of the peat soils in the lowland zone have a wet climate [2].

Peat soil is formed from heaps of dead plant debris, both rotten and fresh. The accumulation of plant residues continues to increase in size and thickness because the decomposition process is hampered by anaerobic conditions. Another cause is environmental conditions that are less conducive to the development of decomposing biota or decomposers. Peat soil formation is a geographical process, due to deposition and transportation processes. The process of peat soil formation takes a very long time, can be thousands of years through a process that varies widely from one place to another. The rate of peat formation in the primary forest is around 0.05 to 0.5 mm per year [3]. Based on the level of maturity, there are 3 (three) types of peat soil, namely sapric (ripe), hemic (half-ripe) and fabric (raw) peat. Based on the level of fertility, peat is divided into 3 types, namely: (a) Eutrophic (fertile) peat rich in mineral and alkaline materials and other elements, (b) Mesotrophic peat is rather fertile peat, has mineral content and is alkaline, (c) Oligotrophic peat is infertile peat, poor in minerals and alkaline [4].

The potential of peatlands for agricultural cultivation is largely determined by aspects of hydrology, soil and the level of technology used [2]. Some of the peatlands are currently abandoned and have been degraded after failing due to inaccuracy in managing them. The problem of the physical properties of peat soil that plays the most role is the reduction in peat thickness (subsidence), irreversible drying and...
low buffering capacity for plants due to low content weight or bulk density (BD) [5]. The chemical constraints of peat soil are poor nutrients, high content of organic acids, which can even poison plants. Peat has an acidic pH, high soil CEC and low alkaline saturation. This condition causes the availability of plant nutrients, especially exchangeable bases such as K, Ca and Mg to below. Likewise, the availability of microelements such as Cu, Zn, Mn and Fe is also low, because these elements are bonded in chelate form.

Technological innovations to increase peat lands productivity have been developed by various research institutions and universities. A series of research results on peatlands show that peat soils are responsive to N, P, K and micro Zn and Cu fertilizers. The NPK dose for cereal plants on peat soil was 90 kg N ha$^{-1}$, 45 kg P$_2$O$_5$ ha$^{-1}$ and 75 kg K$_2$O ha$^{-1}$ [5]. The dose of Cu was 20 kg CuSO$_4$.ha$^{-1}$ and Zn was ZnSO$_4$ 0.05% by soaking rice seeds. To control organic acids, amelioration in the form of polyvalent cations such as Fe and Al, so it is suitable for use on peat soil. The research objective was to assess the effect of P fertilizer formula application on peat lands to sweet corn yield and determine the dosage.

2. Materials and methods

2.1. Materials

The research was conducted on peat soil in Rasau Jaya, Kubu Raya Regency and West Kalimantan in 2019. The main material used was P fertilizer formula containing 14.14% P$_2$O$_5$, 14.85% MgO, 2.6% Cu, 2.88% Zn, 0.53% B and 1.58% moisture content. Based on this data, the fertilizer was classified as a macro primary and secondary compound fertilizer [6,7]. Besides, the P fertilizer contains polyvalent cations such as Fe and Al with a content of about 8.87% Fe and 5.31% Al. Other fertilizers used were urea, SP-36, KCl and kieserite. The indicator crop used was Scada sweet corn. Planting distance of the corn was 75 cm x 25 cm.

2.2. Method

The experimental design used was a randomized block with 9 treatments and repeated 3 (three) times (table 1). The treatments consisted of Control, NK, NPK, NPK + Mg, ¾ NPK and 4 measures of the P fertilizer, namely 350, 700, 1,050 and 1,400 kg ha$^{-1}$. The plot size used was 4 m x 5 m.

| Table 1. Fertilizer treatment in the P fertilizer research on peat soil in Rasau Jaya, Kubu Raya Regency, West Kalimantan |
| --- |
| No | Treatment | Urea (kg ha$^{-1}$) | SP-36 | KCl | Kieserite | The P Fertilizer |
| P1 | Control | 0 | 0 | 0 | 0 | 0 |
| P2 | NK | 350 | 0 | 150 | 0 | 0 |
| P3 | NPK | 350 | 275 | 150 | 0 | 0 |
| P4 | NK + 350 kg ha$^{-1}$ P fertilizer | 350 | 0 | 150 | 0 | 350 |
| P5 | NK + 700 kg ha$^{-1}$ P fertilizer | 350 | 0 | 150 | 0 | 700 |
| P6 | NK + 1,050 kg ha$^{-1}$ P fertilizer | 350 | 0 | 150 | 0 | 1,050 |
| P7 | NK + 1,400 kg ha$^{-1}$ P fertilizer | 350 | 0 | 150 | 0 | 1,400 |
| P8 | ¾ NK + 700 kg ha$^{-1}$ P fertilizer | 262.5 | 0 | 112.5 | 0 | 700 |
| P9 | NPK+ Mg | 350 | 275 | 150 | 312 | 0 |
P fertilizer, SP-36 and Kieserite fertilizer formulas were applied in sequences 7 days before planting corn (DBP). Half doses of urea and KCl were given at the age of 7 days after planting (DAP) sweet corn and the rest was given at the age of 35 DAP. Urea and KCl fertilizers are given in rows within 5 to 10 cm from the corn plant row. The indicator plant used was sweet corn of the Scada variety. The spacing of corn is about 75 cm x 25 cm with one seed per hole. After 5 days after planting, embroidery is done for seeds that do not grow or thinning for plants with more than one plant per hole. Plant maintenance includes controlling soil moisture to keep it moist from planting to fruit ripening, controlling pests and diseases and controlling weeds. Sweet corn was harvested at the age of 78 DAP. The parts of the plant that are harvested are the stems and leaves (biomass) and wet cobs. Samples of plants taken and analyzed for their nutrient content are stems and leaves (biomass). Nutrient uptake is the multiplication of nutrient content and its biomass weight.

Soil chemical properties were observed before the study and after the corn harvest. Soil samples were taken in a composite method at a depth of 0 to 20 cm. Soil chemical analysis consisted of C (Walkley and Black), N (Kjeldahl), pH H2O and pH KCl (1:5), potential P and K (HCl 25%), available P (Bray 1), available K (Morgan), cations exchange and cations exchange capacity (NH4-Acetate 1 M pH 7), exchangeable Al and H (KCl 1M) [8]. To determine the effect of treatment, analysis of variance (ANOVA) was carried out and followed by further test using Duncan's Multiple Range Test (DMRT) at the 5% level. The effectiveness of the fertilizers tested was calculated using Relative Agronomy Effectiveness (RAE). RAE is the relative ratio between the increase in yield due to the use of a fertilizer/repaiyer with the increase in yield with the use of standard fertilizers multiplied by 100 [9] with the formula:

\[
\text{RAE} = \frac{\text{Results of the tested fertilizer treatment} - \text{control}}{\text{Results of standard fertilizer treatment} - \text{control}} \times 100 \%
\]

3. Results and discussion

3.1. The properties of the soil used for the experiment

The preparation of peatlands used for research is carried out by clearing land without burning. The experimental plot was made by clearing the land from wood and branches from plant fragments which were then collected outside the plot. The previous land use was hybrid maize. The peat soil used in the research is classified as hemic, but some are very weathered as sapric. The results of soil analysis taken at the beginning of the experiment showed that the soil had a very high C organic content (50.35%) with a very high cations exchange capacity (CEC) of 109 cmol(+)/kg, acidic soil pH-H2O (3.5), cations exchange Ca and Mg were high, but base saturation (BS) was very low (17%) (table 2). Most of Indonesia's peat soils react from acid to very acid with a pH <4.0. The value of the cations exchange capacity of peat soils is generally high, this is due to the negative charge depending on the pH, which is mostly from the carboxyl and hydroxyl groups of phenols [10]. Aluminum levels were high, but Al saturation was moderate (23.5%). The high Ca and Mg levels were due to the application of lime in previous maize cultivation. Very high organic matter content and low pH, as well as organic acids, become problems to soil fertility. Low soil pH is due to the content of organic acids resulting from the weathering of organic matter.

Change in soil chemical properties after maize harvest showed that the soil reaction (pH) without the P fertilizer application was around 3.6 to 4.0; with the application of 1,050 kg and 1,400 kg P fertilizer ha\(^{-1}\) the soil pH can be improved to 4.4 to 4.8. The P fertilizer applications can increase levels of potential P (HCl 25%) from 69 to 114 mg P\(_2\)O\(_5\) at without P fertilizer treatment to 157 mg at 1,050 kg P fertilizer ha\(^{-1}\) and 351 mg P\(_2\)O\(_5\) at 1,400 kg P fertilizer ha\(^{-1}\) (table 3a). The same thing occurred to the available P (Bray 1), P fertilizer application increasing the available P. The increase in potential P and available P levels is due to the P fertilizer as a source of P fertilizer which contains 14.4% P\(_2\)O\(_5\). The P leaching study using peat soil showed that the Christmas Island Rock Phosphate (CIRP) and the Pugam washed
fertilizer were lower than the NPK and SP-36 fertilizer treatments. Increasing the dosage of P fertilizer application, the greater the P loss through leaching [11]. Pugam fertilizer is P fertilizer enriched with Al and Fe. In acidic peat soils, Al and Fe dissolve and form chelate. The remaining positive charges of Al and Fe become a new adsorption site to bind phosphate anions, thereby reducing the leaching rate. Pugam has a similar formula to the P fertilizer that was used in this research.

Table 2. Chemical properties of peat soil in Rasau Jaya, Kubu Raya, West Kalimantan used for the experiment

| Parameter                      | Unit | Number | Parameter                      | Unit | Number |
|--------------------------------|------|--------|--------------------------------|------|--------|
| C and N Organic                |      |        | Extract of NH₄OAC 1 M pH 7     |      |        |
| C (Walkley & Black)            | %    | 50.35  | Na                             | cmol(+) kg⁻¹ | 0.33   |
| N (Kjeldahl)                   | %    | 1.63   | K                              | cmol(+) kg⁻¹ | 0.92   |
| C/N                            |      | 31     | Ca                             | cmol(+) kg⁻¹ | 11.51  |
| pH-H₂O (1:5)                   | -    | 3.55   | Mg                             | cmol(+) kg⁻¹ | 5.42   |
| pH-KCl (1:5)                   | -    | 2.99   | Sum                            | cmol(+) kg⁻¹ | 18.18  |
| HCl 25% - P₂O₅                 | g 100 g⁻¹ | 84     | CEC                            | cmol(+) kg⁻¹ | 109.1  |
| HCl 25% - K₂O                  | g 100 g⁻¹ | 27     | BS                             | %    | 17     |
| Bray I – P₂O₅                  | ppm  | 76.8   | Exchange Al                    | cmol(+) kg⁻¹ | 6.82   |
| Morgan – K₂O                   | ppm  | 409    | Exchange H                     | cmol(+) kg⁻¹ | 4.59   |
|                                |      |        | Al Saturation                  | %    | 23.5   |

The P fertilizer formula application increases levels of exchange Ca, Mg, base saturation and Fe. The exchange Ca level in the Control was 15.23 cmol(+) kg⁻¹ increasing to 19.9 cmol(+) kg⁻¹, while the exchange level in Control was 9.09 cmol(+) kg⁻¹ increased to 12.65 cmol(+) kg⁻¹ at 1,400 kg P fertilizer ha⁻¹. Base saturation (BS) in Control was around 21% increased to 32% by giving 1,400 kg P fertilizer ha⁻¹. The increase in cations levels was due to the P fertilizer in its formulation using dolomite (table 3b). In peat soils, the micro element content is generally found in very low amounts and can cause deficiency symptoms for plants. Carboxylate and phenolic groups in the reactive site of peat soils can form complex compounds with micro elements, resulting in micro elements becoming unavailable to plants. In addition, there is a strong reduction condition that causes the micro elements to be reduced to their metal forms which are not charged [9].

Table 3a. Chemical properties of peat soil after sweet corn harvest in West Kalimantan

| Treatment                              | Soil pH H₂O | Kjeldahl N % | HCl 25% P₂O₅ mg 100 g⁻¹ | Bray I P₂O₅ ppm | P Retention % |
|----------------------------------------|-------------|--------------|-------------------------|-----------------|---------------|
| Control                                | 4.0         | 3.0          | 2.23                    | 142             | 29            | 276.8 | 8.4   |
| NK                                     | 3.6         | 2.8          | 2.05                    | 69              | 52            | 179.3 | 9.4   |
| NPK                                    | 4.2         | 3.2          | 1.90                    | 88              | 40            | 206.8 | 10.4  |
| NK + 350 kg P fertilizer               | 3.7         | 3.0          | 1.28                    | 92              | 33            | 220.0 | 15.2  |
| NK + 700 kg P fertilizer               | 4.3         | 3.4          | 2.00                    | 130             | 43            | 279.8 | 15.0  |
| NK + 1,050 kg P fertilizer             | 4.4         | 3.4          | 2.47                    | 157             | 29            | 323.0 | 16.0  |
| NK + 1,400 kg P fertilizer             | 4.8         | 3.9          | 2.15                    | 351             | 39            | 917.0 | 9.6   |
| ¾ NK + 700 kg P fertilizer             | 4.2         | 3.4          | 1.77                    | 119             | 49            | 251.9 | 11.6  |
| NPK+ Mg                                | 3.8         | 3.0          | 1.79                    | 114             | 33            | 195.4 | 10.4  |
Table 3b. Properties of peat soils after corn harvest in West Kalimantan (continued)

| Treatment                  | Cations Exchange | CEC | BS | Pirofosfat |
|----------------------------|------------------|-----|----|------------|
|                            | Ca | Mg | K | Na | Sum | % | % | % |
| Control                    | 15.23 | 9.09 | 0.57 | 0.39 | 25.28 | 118.87 | 21 | 0.74 | 0.26 |
| NK                         | 12.09 | 7.15 | 1.04 | 0.34 | 20.62 | 119.24 | 17 | 0.29 | 0.17 |
| NPK                        | 16.61 | 11.09 | 0.78 | 0.45 | 28.93 | 120.93 | 24 | 0.41 | 0.17 |
| NK + 350 kg P fertilizer   | 12.18 | 8.10 | 0.65 | 0.37 | 21.30 | 109.51 | 19 | 0.30 | 0.17 |
| NK + 700 kg P fertilizer   | 15.59 | 9.60 | 0.85 | 0.52 | 26.56 | 102.20 | 26 | 0.45 | 0.23 |
| NK + 1,050 kg P fertilizer | 15.73 | 9.80 | 0.56 | 0.73 | 26.82 | 100.84 | 27 | 0.55 | 0.24 |
| NK + 1,400 kg P fertilizer | 19.90 | 12.65 | 0.77 | 1.69 | 35.01 | 108.21 | 32 | 0.73 | 0.32 |
| ¾ NK + 700 kg P fertilizer | 19.51 | 2.40 | 0.96 | 3.51 | 26.38 | 115.00 | 23 | 0.44 | 0.24 |
| NPK+ Mg                    | 13.30 | 8.44 | 0.64 | 6.80 | 29.18 | 112.92 | 26 | 0.56 | 0.23 |

3.2. Plant growth

Corn grown on peat soil in the Control treatment showed stunted languid growth, pale leaf color, inhibited pollen formation, resulting in small cobs and inadequate seeds. This condition reflects that the cultivation of maize on peat soil without fertilizer treatment will not be effective, because peat soil is classified as nutrient-poor soil, with high levels of organic acids that can toxic plants.

At the age of 8 weeks after planting (WAP), the highest maize plant height of 224 cm was achieved by treatment of 1.4 t P fertilizer ha\(^{-1}\). The shortest maize plant height was produced by Control treatment, namely 127 cm. The NK and NPK+Mg treatments produced significantly different plant height and higher than the control. The P fertilizer treatment (P4 to P8) resulted in plant height of 201 to 224 cm which was significantly different and higher than that of NP, NPK and NPK+Mg treatments (table 4). Increasing the P fertilizer dose from 0 to 1,400 kg ha\(^{-1}\) was always followed by an increase in plant height. In other words, the application of P fertilizer to peat soils improves soil chemical properties, which is reflected by the better growth of maize than without P fertilizer.

Table 4. Effect of treatment on sweet corn plant height in Rasau Jaya, Kubu Raya, West Kalimantan

| No | Treatment                  | Plant Height (cm) |
|----|----------------------------|-------------------|
|    |                            | 2 WAP\(^1\) | 4 WAP | 6 WAP | 8 WAP |
| P1 | Control                    | 22 a\(^2\) | 47 a  | 74 a  | 127 a |
| P2 | NK                         | 33 b  | 67 bcd | 95 b  | 173 b |
| P3 | NPK                        | 29 ab | 68 cd  | 106 bc | 187 c |
| P4 | NK + 350 kg P fertilizer   | 29 ab | 82 bcd | 117 cd | 202 d |
| P5 | NK + 700 kg P fertilizer   | 34 b  | 84 cde | 125 de | 209 e |
| P6 | NK + 1,050 kg P fertilizer | 36 b  | 92 e   | 143 fg | 214 e |
| P7 | NK + 1,400 kg P fertilizer | 29 b  | 92 e   | 144 g  | 224 f |
| P8 | ¾ NK + 700 kg P fertilizer | 40 b  | 82 cde | 136 ef  | 199 d |
| P9 | NPK+ Mg                    | 34 ab | 67 ab  | 95 b   | 174 b |
|    | CV (%)                     | 21  | 20     | 21     | 15    |

\(^1\)WAP = week after planting
\(^2\)The numbers accompanied by the same letter in the same column are not significantly different in Duncan's 5% test.

The number of corn leaves counted as the number of corn leaves that were still attached to the corn stalk during observation. At the age of 8 weeks after planting (WAP) giving NPK+Mg (P9) fertilizer resulted in 9.5 pieces of corn leaves which were not significantly different from control (P1) of 8.7 pieces. Treatment of NK fertilizer (P2) was 10 pieces and NPK fertilizer (P3) was 10.3 pieces. The application of P fertilizer resulted in 11.3 to 12.3 pieces which were significantly different than the
application of NK, NPK and NPK+Mg fertilizers (table 5). In other words, giving P fertilizer increases the growth of maize plants which is reflected by an increase in plant height and number of leaves of maize.

Table 5. Effect of treatment on the number of maize leaves of maize in Rasau Jaya, Kubu Raya, West Kalimantan

| No | Treatment                        | Number of corn leaves (pieces) |
|----|----------------------------------|--------------------------------|
|    |                                  | 2 WAP | 4 WAP | 6 WAP | 8 WAP |
| P1 | Control                          | 3.7 a | 4.3 a | 5.6 a | 8.7 a |
| P2 | NK                               | 4.5 b | 5.9 bcd | 6.8 b | 10.0 b |
| P3 | NPK                              | 4.3 ab | 5.6 bc | 7.3 bc | 10.3 bc |
| P4 | NK + 350 kg P fertilizer         | 4.3 ab | 5.8 bcd | 7.7 cd | 11.5 d |
| P5 | NK + 700 kg P fertilizer         | 4.9 b | 6.1 cde | 8.3 cd | 11.9 d |
| P6 | NK + 1,050 kg P fertilizer       | 5.1 b | 6.6 de | 9.1 de | 12.3 d |
| P7 | NK + 1,400 kg P fertilizer       | 4.5 b | 7.0 e | 9.5 e | 11.9 d |
| P8 | ¾ NK + 700 kg P fertilizer       | 4.9 b | 6.3 cde | 8.9 ef | 11.3 cd |
| P9 | NPK+ Mg                          | 4.3 ab | 5.0 ab | 6.9 b | 9.5 ab |
|    | CV (%)                           | 12     | 15     | 16     | 12     |

1) WAP = week after planting
2) The numbers accompanied by the same letter in the same column are not significantly different in Duncan's 5% test.

3.3. Corn yield

Sweet corn varieties Scada harvested around the age of about 78 days after planting (DAT). The Control treatment produced the shortest cob length, which was 12.6 cm and significantly different from the NK, NPK and P fertilizer treatments which produced cob lengths of about 17.8 to 19.5 cm. Although not significantly different, the P fertilizer treatment resulted in a longer ear length of 19.3 to 19.5 cm compared to the NK, NPK and NPK+Mg treatments which produced ear lengths of around 17.6 to 18.4 cm. The P fertilizer treatment (P4 to P8) resulted in corn cob diameter ranging from 4.3 to 4.8 cm which was significantly different from the treatment of NK, NPK, NPK+Mg (table 6). These results indicate that the P fertilizer treatment can improve the quality of corn cobs, both in diameter and ear length. Also, the P fertilizer treatment made the corn grains pithy, this was indicated by the weight of the cobs.

Treatment Control, NK, NPK, NPK+Mg yielded wet biomass (stems and leaves) and cobs at harvest were not significantly different between treatments. The weight of wet biomass produced by this treatment was around 6.42 t ha⁻¹ in the Control, 8.03 t ha⁻¹ in the NK treatment and 8.18 t ha⁻¹ in the NPK treatment and 7.54 t ha⁻¹ in the NPK+Mg treatment. Giving NK coupled with P fertilizer increased the yield of biomass which was significantly different from the NK and NPK+Mg treatments. Treatment of NK+700 kg P fertilizer ha⁻¹ increased 77% of maize biomass compared to NPK+Mg treatment or 47% compared to NK treatment. The highest wet biomass yield of 15.3 t ha⁻¹ was achieved in the treatment of NK+1.4 t P fertilizer ha⁻¹.

The relative agronomic effectiveness (RAE) is the relative value comparing the treatment tested with the standard treatment, in this case, the NPK+Mg treatment. The RAE value for standard treatment is 100 (one hundred), while the RAE value for the Control treatment is 0 (zero). If the treatment tested has an RAE value up to 100, it indicates that the treatment tested is better than the standard treatment; otherwise, the tested treatment is not effective compared to the standard treatment. From the results of the RAE value analysis, it is known that all P fertilizer treatments produce RAE values above 100%, so the fertilizer is considered effective compared to standard fertilizers (NPK+Mg) (table 6). Although the dose of NK fertilizer is reduced to ¾ dose, P fertilizer is more effective than NPK fertilizer treatment.
Table 6. Effect of treatments on biomass weight and wet cobs during corn harvest in the P fertilizer research in West Kalimantan

| Perlakuan | Cob Length cm | Cob Diameter cm | Biomass Wet t ha⁻¹ | Cob Wet t ha⁻¹ | RAE(1) |
|-----------|---------------|-----------------|---------------------|----------------|--------|
| Control   | 12.6 a ²)     | 2.9 a           | 6.42 a              | 6.64 a         | 0      |
| NK        | 18.4 b        | 4.3 a           | 8.03 a              | 9.09 a         | 157    |
| NPK       | 17.8 b        | 4.3 a           | 8.18 a              | 8.88 a         | 143    |
| NK + 350 kg P fertilizer | 19.3 b | 4.5 b | 11.89 b | 13.40 b | 433 |
| NK + 700 kg P fertilizer | 18.9 b | 4.6 b | 11.55 b | 13.47 b | 438 |
| NK + 1,050 kg P Fertilizer | 19.5 b | 4.8 b | 13.51 b | 14.00 b | 472 |
| NK + 1,400 kg P fertilizer | 19.5 b | 4.7 b | 15.25 c | 15.18 b | 547 |
| ¾ NK + 700 kg P fertilizer | 19.3 b | 4.8 b | 12.96 bc | 13.33 b | 429 |
| NPK+ Mg   | 17.6 b        | 3.9 a           | 7.66 a              | 8.20 a         | 100    |
| CV (%)    | 12            | 15              | 30                  | 31             |        |

1) RAE = relative agronomic effectiveness
2) The numbers accompanied by the same letter in the same column are not significantly different in Duncan's 5% test.

Sweet corn that is harvested and consumed which has economic value is young cobs, so the harvest time is very important to be met to get optimal results. Treatment control, NK, NPK and NPK+Mg resulted in wet cob weight which was not significantly different between treatments. Cob weight for this treatment was about 6.64 to 9.09 t ha⁻¹. Giving NK+700 kg ha⁻¹ P fertilizer resulted in a significantly different weight of corn cobs compared to giving NK and NPK+Mg, it could even produce twice more wet cobs. Treatment of NK+700 kg P ha⁻¹ fertilizer increased the weight of corn cobs by 51% higher than NPK+Mg treatment or 43% higher than NK. Based on figure 1, it is known that the maximum yield of wet corn cobs (Y_max) is achieved at a dose of 1,400 kg ha⁻¹ P fertilizer. Maximum yield targets are rarely used with considerations less economical because the additional input must be balanced with a real increase in yield. What is more realistic and commonly used is to use an optimum yield target of around 90% to 95% maximum yield, in that condition, there is still an increase in yield and economically it is still profitable. Based on this equation, to achieve the optimum target of 90% and 95%, the P fertilizer dosage is 680 kg ha⁻¹ and 890 kg ha⁻¹.

The use of NPK+Mg fertilizer (P 9) had nutrients equivalent to the treatment of NK+700 kg ha⁻¹ P fertilizer (P 5). Based on table 6, the treatment of NK+700 kg ha⁻¹ P fertilizer resulted in a cob weight of 13.47 t ha⁻¹ which was significantly different than NPK+Mg with a yield of 8.20 t ha⁻¹. These results indicate that P fertilizer has another advantage over a single NPK+Mg. The P fertilizer excellence is formulated from PS Grade and dolomite which in its solvent produces polyvalent cations and can bind toxic organic acids in peat soil.

Control, NK, NPK and NPK+Mg treatments resulted in N nutrient uptake in biomass of 22.27 to 42.19 kg N ha⁻¹ which was not significantly different between treatments. The application of NK fertilizer accompanied by the application of P fertilizer increased the uptake of N biomass which was significantly different than without P fertilizer treatments (table 7). Increasing the P fertilizer dose to a certain dose was followed by an increase in N uptake. Treatment of 700 kg ha⁻¹ P fertilizer resulted in N uptake of 66.76 kg N ha⁻¹ which was not significantly different from the doses of 1,050 kg and 1,400 kg ha⁻¹ P fertilizer ha⁻¹. In the application of NK fertilizer, the treatment of NK+700 kg ha⁻¹ P fertilizer resulted in N uptake of 64.09 kg ha⁻¹ which was higher and significantly different than that of NK treatment which resulted in N uptake of 35.52 kg ha⁻¹, or an increase of 81%.
The same trend as the N absorption pattern was found in the P, K and Ca, Mg and Fe absorption. The treatments without P fertilizer, namely Control, NK and NPK were not significantly different in the uptake of P, Ca, Mg and Fe. The P fertilizer treatments resulted in higher and significantly different uptake of P, K, Ca, Mg and Fe compared to without control. The higher the P fertilizer dose given the higher P, K, Ca, Mg and Fe uptake as well. The highest P, K, Ca, Mg and Fe uptake was yielded by NP+1,400 kg ha$^{-1}$ P fertilizer, each of 18.84 kg P ha$^{-1}$, 58.01 kg K ha$^{-1}$, 14.66 kg Ca ha$^{-1}$, 1,957 kg Mg ha$^{-1}$ and 662 g Fe ha$^{-1}$. This absorption result strengthens the previous statement, that the application of the P fertilizer improves soil properties that affect the growth of corn plants.

**Table 7. Effect of treatment on nutrient uptake of N, P, K, Ca, Mg and Fe in maize biomass**

| Treatment                      | N   | P   | K   | Ca  | Mg  | Fe  |
|--------------------------------|-----|-----|-----|-----|-----|-----|
| Control                        | 27.27 a$^{1)}$ | 6.86 a | 14.67 a | 4.31 a | 6.25 a | 304 ab |
| NK                             | 35.52 a | 8.15 ab | 30.86 bc | 5.76 abc | 6.96 a | 332 ab |
| NPK                            | 40.97 a | 8.71 ab | 23.15 ab | 5.32 ab | 7.68 a | 269 a |
| NK + 350 kg P fertilizer       | 46.97 ab | 9.84 abc | 44.26 cde | 7.15 abc | 9.19 ab | 440 b |
| NK + 700 kg P fertilizer       | 66.76 c | 11.47 bc | 41.57 cd | 6.92 abc | 9.99 ab | 382 ab |
| NK + 1,050 kg Peatpos          | 63.78 bc | 12.45 bc | 50.03 de | 8.81 c | 12.21 b | 452 b |
| NK + 1,400 kg P fertilizer     | 81.73 c | 18.84 d | 58.01 e | 14.66 d | 19.57 c | 662 d |
| ¾ NK + 700 kg P fertilizer     | 64.09 bc | 14.08 c | 36.97 abc | 11.85 d | 13.26 b | 437 c |
| NPK+ Mg                        | 42.19 a | 12.38 bc | 31.34 bc | 7.76 bc | 7.63 a | 327 ab |
| CV (%)                         | 37   | 35   | 39   | 43  | 43  | 33  |

1) The numbers accompanied by the same letter in the same column are not significantly different in Duncan's 5% test

### 4. Conclusions

The P fertilizer applied to peat soil in Rasau Jaya, Kubu Raya Regency, West Kalimantan can improve soil chemical properties, including increasing soil pH, available and potential P and base saturation. The P fertilizer effective in increasing plant growth and yield of sweet corn compared to standard NPK+Mg fertilizers treatment. The P fertilizer increased nutrient uptake of N, P, K, Ca, Mg and Fe in corn biomass compared to without P fertilizer treatments. The optimum P fertilizer dosage for sweet corn planted on
peat is around 670 to 890 kg ha$^{-1}$. In this dosage range, P fertilizer yielded 13.2 to 13.9 t of wet corn cobs ha$^{-1}$.

References
[1] BSDLP 2015 *Sumber Daya Lahan Pertanian Indonesia: Luas, Penyebaran, dan Potensi Ketersediaan*. Editor Husen E, Agus F and Nursyamsi D (in Bahasa) (Bogor: Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian Bogor).
[2] Anwar K, Subardja D and Subiksa I G M 2014 Potensi dan Karakterisasi Lahan Pasang Surut di Indonesia in Nursyamsi D et al. (eds) *Teknologi Inovasi Lahan Rawa Pasang Surut Mendukung Kedaulatan Pangan Nasional I* (in Bahasa) (Jakarta: IAARD Press) pp 23–48.
[3] Noor M, Masganti and Agus F 2014 Pembentukan dan Karakteristik Gambut Tropika Indonesia in Agus F et al. (eds) *Lahan Gambut Indonesia: Pembentukan, Karakterisasi, dan Potensi Mendukung Ketahanan Pangan Nasional* (in Bahasa). Revisi. (Jakarta: IAARD) pp 7–32.
[4] Agus F and Subiksa I G M 2008 *Lahan Gambut: Potensi untuk Pertanian dan Aspek Lingkungan* (In Bahasa) (Bogor: Balai Penelitian Tanah and ICRAF)
[5] Suriadikarta D A 2009 Pembelajaran dari kegagalan Pengelolaan lahan gambut (PLG) sejuta hektar menuju PLG berkelanjutan *Oraji Pengukuhan Profesor Riset Bidang Kesuburan Tanah* (In Bahasa) (Jakarta: Badan Penelitian dan Pengembangan Pertanian Kementerian Pertanian)
[6] Kementan 2017 *Peraturan Menteri Pertanian NO 36/Permentan/SR/10/2017 tentang Pendaftaran Pupuk An-organik* (in Bahasa) (Jakarta: Kementerian Pertanian)
[7] Kementan 2018 *Peraturan Menteri Pertanian No 209/Permentan/Kpts/SR.320/3/2018 tentang Persyaratan Teknis Minimal Pupuk An-organik* (in Bahasa) (Jakarta: Kementerian Pertanian)
[8] Badan Penelitian dan Pengembangan Pertanian 2012 *Petunjuk Teknis Analisis Kimia Tanah, Tanaman, Air, dan Pupuk* Edisi 2 (in Bahasa)
[9] Machay A D, Syers J K and Gregg P E H 1984 Ability of chemical extraction procedures to assess the agronomic effectiveness of phosphate rock materials *New Zealand Journal of Agriculture Research* 27 219–230
[10] Hartatik W 2008 Pemanfaatan Fosfat Alam Pada Lahan Gambut *Penggunaan Fosfat Alam Sebagai Sumber Pupuk P* (in Bahasa) (Bogor: Balai Penelitian Tanah) pp 84-109 http://balittanah.litbang.pertanian.go.id/ind/dokument/buku/fosfatanam/wiwik.pdf
[11] Subiksa I G M 2018 Perbandingan pengaruh beberapa jenis pupuk mengandung fosfat terhadap kehilangan hara melalui pelindian pada tanah gambut (in Bahasa) *Sub optimal land journal* 7(1) 1-13