Productivity of soybean under palm oil plantation on tidal swamps due to several packages of technology

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Abstract. The research was aimed to determine soybean productivity in various technological packages for soybean cultivation under palm oil plantations on tidal swamps. The research was conducted in Barito Kuala, South Kalimantan, using a randomized block design with four replications. The treatment consists of six technological packages, namely: (1) farmer’s technology, (2) recommendation, (3) improvement-1, (4) improvement-2, (5) improvement-3, and (6) improvement-4. The results indicate that plantations of oil palm on type C tidal swamps is suitable for soybean development. On the tidal swamps with pH soils 4.30, low of K and Ca, recommendation technology can increase pH soils from 4.30 to 5.15; availability of P, Ca and Mg; N and K uptake; plant weight; filled pods and increase seed yields 86% from farmer’s technology 1.00 to 1.86 t/ha. Improvement-1 technology increase pH soils from 4.30 to 6.05; nutrient availability (N, P, K, Ca and Mg); K uptake; plant weight; root nodules; filled pods and increase seed yields 100% from farmer’s technology 1.00 to 2.00 t/ha. Increased doses of dolomite, organic, N and P fertilizers from improvement-1 technological packages did not significantly increase seeds yield. This finding suggest that for developing soybean on tidal swamps, recommendation or improvements-1 technological packages could be recommended.

1. Introduction
Among the food crops, soybean in Indonesia have a third strategic value after rice and corn. Its diverse uses of root nodules and plant litter that can improve soil fertility, place the development of soybean plants in harmony with efforts to realize sustainable bio-industry farming systems [1]. Effort for increasing soybean production have been done least since last one half decade. However, until 2017 domestic soybean production (0.54 million ton) cannot meet the national demand whic is reaches 2.4 million ha, mostly spread in Sumatera, Kalimantan, Papua, and Sulawesi islands [7]. In Indonesia, the problems to achieve soybean self-sufficiency is the narrow harvest area and low productivity, which is only 0.35 million ha with productivity 1.51 t/ha [2]. To achieves soybean self-sufficiency, it is still requiring increases harvest area and productivity [4,5] at least 1.8 million ha with productivity 1.60 t/ha [6]. Meanwhile, the farmers are still less interested to planting soybeans because its less profitable compared the other secondary crops, especially maize. To solved the problem, developing soybeans must be done into the lands that are not commonly used for secondary crops, i.e. on the young oil palm plantations of tidal swamps.

In Indonesia, tidal swamps are around 8.9 million ha, mostly spread in Sumatera, Kalimantan, Papua, and Sulawesi islands [7]. However only about 5.2 million ha of such land is available for agriculture including soybean, especially in the oil palm plantations that are less than three years old [8]. The plantation of oil palm in Indonesia 2013 is reached 13.5 million ha, with addition rate of 450 thousand ha/year [9]. Constraints of soybean growth in the oil palm plantations on tidal swamps are shaded by oil
palm plants, water saturated in the roots, acidic soil, toxicity of Al, Fe, and Mn, deficiencies of N, P, K, Ca, and Mg [10,11]. Soybean plants that are poisoned by Al, the root growth are short and thickened. This can cause the decrease of nutrients uptake, especially P which is important for cell growth and photosynthesis [12,13]. The excessive accumulation of Fe has been linked to oxidative damage to proteins, lipids, and losses in chlorophyll content [14], so that the photosynthetic process that is important for growth and crop yields is not optimal.

In order to develop soybeans in young oil palm plantation on tidal lands, several research results show that the use of tolerant varieties on tidal swamps, using of soil ameliorants, appropriate of NPK fertilizers, and rhizobium inoculation are reported able to improve soybean growth and yield of soybean on tidal swamps [10,15]. Anjasmoro soybean variety, under good soil and crops management practices are able to yield 2.11 t/ha on tidal swamps in Jambi [16] and 2.64 t/ha in South Sumatra [15]. Development of soybeans in the oil palm plantation area, need to use shade tolerant soybean varieties, must also be accompanied by improved soil fertility through amelioration with lime (dolomite or calcite) and organic matter, as well as fertilizing N, P, and K. Soybean production techniques on plantation oil palm is the same as cultivating soybeans in acidic dry land and dry land [17]. Anjasmoro variety soybean was superior to Nanti variety soybean, which were planted under four-year-old oil palm plantation [18]. These studies indicate that tidal land has good prospects for soybeans development, although to achieve high yields it requires a specific technological package. The constraints on the development of soybeans on tidal land in South Kalimantan in terms of socio-economic aspects are the low level of education and skills of farmers, the strength of traditional cultural customs, and limited energy and capital [19]. External factors that become obstacles are limited supporting infrastructure, especially the water management network, low location accessibility, and undeveloped agribusiness institutions. In order to have competitiveness against other food crops, soybean on type C tidal land in South Kalimantan must be able to produce >3 ton/ha, or have a high price. It these requirements are not met, soybeans will be difficult to develop on tidal land in South Kalimantan. The research was aimed to determine soybean productivity in various technological packages for soybean cultivation under palm oil plantations on tidal swamps.

2. Methods
The research was conducted on type C of tidal swamp lands in Sidomulyo Village, sub-district of Wanaraya, Barito Kuala of South Kalimantan. The research was conducted in April to July 2015. The land used is oil palm plantation two years old (plant spacing of 6 m x 5 m). The soybean used in each technological package was Anjasmoro variety. The experimental design used was randomized block design with four replications. The treatments studied were six technological packages (Table 1). Each treatment was planted in the experimental plots under oil palm rows measuring of 4 m x 5 m, plants spacing 40 cm x 15 cm, 2 plants per hole, except the treatment of soybean farmer’s technology where it used irregular plant spacing.

At the beginning of the experiment and during pod filling at 65 days after planting (DAP), a composite soil sample was collected, at a depth of 0-20 cm. The soil sample was analyzed for soil pH, organic C, total N, P2O5, K, Na, Ca, Mg, exchangeable Al, CEC, Al saturation, Mn, and Fe in the soils. Observations of plant height at 45 DAP, leaf chlorophyll index at 45 and 65 DAP, number of root nodules at 45 and 65 DAP, leaf NPK content at 40 and 60 DAP, and stems dry weight at the maximum vegetative growth. Observations made during the harvest were number of filled pods per plant, 100 seeds dry weight, and seed yield per hectare.

The dose of dolomite to reduce saturation of Al-exchanged soil to an estimated 20% and 10% was determined by using formula 1:

$$BD = \{Al - \text{exch. Saturation} - 0.20\} \times CEC_{\text{Effective}} \times Y$$

BD : The amount of dolomite that must be given (t/ha)
Al- exch. : The saturation level of Al-exch. in the percent, for example 40% is written 0.40
0.20 : The tolerance level of soybean plants to Al- exch. saturation.
CEC-Effective : The CEC value at the original soil pH is obtained by summing the base cation (Ca, Mg, K, Na), H, and Al which are absorbed on the soils surface complex, or that can be exchanged.

Y : Correction factor, the value is 1.51 if it using dolomite, and 1.65 if it using calcite limestone.

Based on this formula, the need of dolomite to reduce the saturation of soil Al exchangeable in this study from 44.13% to around 20 and 10% (Table 2). Thus, its requires dolomite 4.0 t/ha and 5.7 t/ha respectively.

Table 1. The technological packages for soybean cultivation tested on tidal swamps at Barito Kuala.

| Inputs                  | Farmers               | Recommendation       | Improvement 1 | Improvement 2 | Improvement 3 | Improvement 4 |
|-------------------------|-----------------------|----------------------|---------------|---------------|---------------|---------------|
| 1. Soil                 | Light soil tillage    | Light soil tillage   | Light soil tillage | Light soil tillage | Light soil tillage | Light soil tillage |
| 2. Drainage canel       | Every width of bed 4 m| Every width of bed 4 m| Every width of bed 4 m | Every width of bed 4 m | Every width of bed 4 m | Every width of bed 4 m |
| 3. Herbicide            | 5 days before planting| 5 days before planting| 5 days before planting | 5 days before planting | 5 days before planting | 5 days before planting |
| 4. Plants spacing       | Random                | Random               | Random        | Random        | Random        | Random        |
| 5. Foliar fertilizer    | Gandasi D 2x, Gandasi B 2x | 0                   | 0             | 0             | 0             | 0             |
| 6. Phonska (kg/ha)      | 0                     | 150                  | 0             | 0             | 0             | 0             |
| 7. Urea (kg/ha)         | 0                     | 50                   | 50            | 100           | 50            | 100           |
| 8. SP36 (kg/ha)         | 0                     | 100                  | 75            | 150           | 75            | 150           |
| 9. KCl (kg/ha)          | 0                     | 0                    | 50            | 50            | 50            | 50            |
| 10. Organic fertilizer  | 0                     | 1500                 | 1250          | 2500          | 1250          | 2500          |
| 11. Dolomite (t/ha)     | 0                     | 1.0                  | Until saturated of Al soil 20% | Until saturated of Al soil 20% | Until saturated of Al soil 10% | Until saturated of Al soil 20% |
| 12. Agnosoryh izobatum  | 0                     | 0                    | Untill saturated of Al soil 0.3 | Untill saturated of Al soil 0.3 | Untill saturated of Al soil 0.3 | Untill saturated of Al soil 0.3 |
| 13. Abascular mycorrhzal (kg/ha) | 0          | 0                    | 5.0           | 0             | 5.0           | 0             |
| 14. Pest control        | Intensive             | Intensive            | Intensive     | Intensive     | Intensive     | Intensive     |
| 15. Diseases control    | Intensive             | Intensive            | Intensive     | Intensive     | Intensive     | Intensive     |

3. Results and discussion

3.1. Chemical properties of soil

In the two years old of oil palm plantation, the land under the row of oil palm plants that can be planted for soybeans is around 70%. The soil characters in the research site was classified as very acidic, with soils pH is 4.30 (Table 2). On this conditions, the availability of soil nutrients is relatively low, especially N, Ca, and Na. Aluminium (Al) saturation which is greatly influences the growth of soybean plant, reaching 44.13%. The soils properties are classified as less suitable to support the growth of soybean plants in order get optimally plant growth and high yield [21]. In the low pH with high Al saturation, the roots of soybean cannot be develope and root nodules are not well formed [6], so that nutrient uptake and nitrogen fixation by plant root nodules are not optimal. Soybean plants will grow well if the Al saturation can be reduced to around 20% [21].
The soil chemical properties after treatments of the technological packages when soybean plants aged 60 days after planting (DAP), showed that additions of 1000 kg dolomite/ha (recommendation technology) was able to increase soil pH from pH 4.65 to pH 5.15 compared to farmer’s technology which was not applied dolomite (Table 3). The improvement of technological package 1-4 increases soil pH higher than recommendation technology package. This is due to doses of dolomite of technology package 1-4 higher compared with recommendation technology, which reached 4.08 t/ha and 5.78 t/ha on the target to decreases the soils Al saturation up to 20% and 10% respectively. Giving 1000 kg dolomite/ha on the recommendation technology increase pH from 4.30 to 5.15. The improvement technology package 1-4 are able increase soil pH from 4.30 (farmers technology) to 6.05-6.55 (Table 4). Increased soil pH was significantly increased plant N uptake of 53.2%, plant P uptake of 31.1%, and plant dry weight of 30.5% in several soybean varieties [22].

Table 2. Soil chemical properties before planting in tidal swamps of Wanaraya, Barito Kuala.

| Soil chemical properties | Value | Adequate |
|-------------------------|-------|----------|
| pH H2O                  | 4.30  | 6.6-7.5  |
| Organic C (%)           | 2.10  | 2.01-3.0 |
| N-total (%)             | 0.35  | 0.21-0.50|
| P2O5 (ppm)              | 81.1  | 11-15    |
| K (me/100 g)            | 0.31  | 0.4-0.5  |
| Na (me/100 g)           | 0.49  | 0.4-0.7  |
| Ca (me/100 g)           | 2.48  | 6-10     |
| Mg (me/100 g)           | 1.24  | 1.1-2.0  |
| Al exch. (me/100 g)     | 4.97  | 8        |
| H-exch. (me/100 g)      | 1.77  | -        |
| CEC Effict              | 11.26 | 17-24    |
| Al saturation (%)       | 44.13 | 11-20    |
| Fe (ppm)                | 179.00| 4.5      |
| Mn (ppm)                | 0.94  | 1.0      |

The treatment of farmer’s technology, recommendations, and 1-4 improvement technology packages have almost the same organic C content (Table 3). Giving organic matter, both manure and compost, is often unable to change the soil C-organic status in a short time. The additions of 5000 kg/ha organic matter in acid soils in Lampung could not increase the C-organic content, but increased the concentration of labile C fraction, namely C water soluble, and C microbiomass [23]. The total N content in the soil increases with the introduction of recommended technology packages or 1-4 improvement technologies (Table 3). This increase can be caused by an increase of soil pH, because nutrient solubility in the soil is strongly influenced by soil pH. Nutrient solubility generally increases with increasing of soil pH to near neutral. The increase of total N content is also likely to be caused by the increase of microorganism’s activity that decompose organic matter caused by increased of soil pH. Giving N fertilizer of 100 Urea kg/ha in the improvement technology 2 and 4 does not increase the N total in the soil, and it’s almost same as the treatment fertilized 50 Urea kg/ha.

Table 3. Effect of several technological packages on soil chemical properties during pod filling (65 DAP) in tidal swamps.

| Technological package | Soil pH | Organic C (%) | N-total (%) | P (ppm) | P2O5 | K-dd (cmol/kg) | Ca-dd (cmol/kg) | Mg-dd (cmol/kg) | CEC (cmol/kg) |
|-----------------------|---------|---------------|-------------|---------|------|---------------|----------------|----------------|---------------|
| Farmers               | 4.65    | 7.32          | 0.43        | 32.6    | 0.26 | 16.6          | 5.1            | 33.6           |
| Recommendation        | 5.15    | 7.08          | 0.50        | 103.3   | 0.29 | 22.5          | 9.9            | 41.8           |
| Improvement-1         | 6.05    | 7.91          | 0.53        | 76.7    | 0.36 | 33.0          | 20.4           | 45.6           |
| Improvement-2         | 6.55    | 7.65          | 0.45        | 94.4    | 0.51 | 34.9          | 21.1           | 47.1           |
| Improvement-3         | 6.55    | 7.75          | 0.44        | 75.1    | 0.38 | 33.7          | 16.8           | 40.3           |
| Improvement-4         | 6.30    | 7.33          | 0.46        | 133.5   | 0.38 | 27.7          | 15.5           | 39.3           |

The treatment of recommendations and improvement technologies 1-4 increases P availability by more than 100% as compared to farmer’s technology (Table 3). This increase is suspected due to of dolomite which is increases soil pH. At the low pH, availability P in the soil is low due to the binding
of P by Al or Fe. The optimum nutrient adequacy for soybean growth is 50 ppm \( P_{2O5} \) (P Bray I), the treatment of recommendations and improvement technology package 1 has been able to support soybean growth for P adequacy. Fertilization of 100 kg SP-36/ha (recommendation technology) and 150 kg SP-36/ha (improvements technology 2 and 4) increased P availability compared to the treatment of 75 kg SP-36/ha (improvement technology 1 and 3) and farmer’s technology.

The K content in the soils increased due to K fertilization. In the improvement technology package 1-4 which is fertilized by 50 kg KCl/ha has a higher K concentration than that of farmer’s technology package and recommendations package (Table 3). The adequacy limit of K for soybean growth is 3 Cmol/kg; this is indicating that in Sidomulyo Village to obtain optimum soybean growth, additional K fertilization is required.

The additions of dolomite based on soils Al saturation around 20% and 10% has a higher Ca concentration than the additions of 1000 kg dolomite/ha (recommendation technology) and without dolomite (farmer’s technology) (Table 3). The additions of larger amounts of dolomite with the addition of manure can reduce the availability of Ca in the soil (improvement technology 3 and 4), when compared to the additions of lower dosage of dolomite (improvement technology 1 and 2). Giving dolomite and manure to acid soils as well as tidal land must be done carefully because it could reduce Ca availability. This is due to manure which is a source of negatively charged organic material that can bind Ca cations, so that the availability of Ca decreases. Giving dolomite also increases Mg in the soil. The treatment of 1-4 improvement technology produces higher Mg content compared to recommendation and farmer’s technology. Like the Ca content, there is a tendency for greater amounts of dolomite accompanied by the addition of manure to reduce the availability of Mg in the soil (Table 3). Cation Exchange Capacity (CEC) at the trial location is high and meets the requirements needed by soybean plants. Land suitability for growing soybean conditions associated with CEC is more than 25 Cmol/kg (very suitable). In Sidomulyo, the additions of dolomite increases CEC. The highest increase through the treatment of dolomite was 20% of Al saturation (Table 3).

3.2. NPK Uptake
Nitrogen content of soybean leaf at the age of 40 DAP ranged from 2.48 (farmer’s technology) to 3.54% (improvement technology 3). There was a tendency that additions dolomite increases N contain in the leaf (Figure 1). The N levels in the leaf increased from 3.67 to 5.08% followed by the increasing of soybean age beginning from 40 DAP to 60 DAP. The adequacy limit of N for soybean plants at upper fully developed leaf sampled prior to initial flowering ranges from 4.25-5.50% [24]. Based on these criteria, soybean plants at 40 DAP on farmer’s technology which is only use leaf fertilizer of Gandasil D and Gandasil B have not been able to meet the needs of plants. Meanwhile, recommendations technology by using Urea fertilizer 50 kg/ha + 150 kg/ha Phonska (NPK), improvement technology package 1 and 3 which also uses Urea 50 kg/ha + inoculation rhizobium, the N nutrient content at the 40 DAP is relatively higher even though it is still below limit of adequacy. During the pod filling period (60 DAP), N nutrient content in the farmer’s technology package is still inadequate category. In the recommendation technology package, improvement technological package 2 and 3 which is using rhizobium (Agrisoy) inoculation, the N content in the leaf is already in the sufficient category, which is above 4.0% (Figure 1). Rhizobium inoculation significantly improved the uptake of N in soybean shoots over un-inoculated soybean [25].

The P nutrient content of soybean plants at 40 DAP in the all treatments was almost having the same value i.e. beginning from 0.28% to 0.31% (Figure 2). The nutrient content of P on the farmer’s technological treatment until the 4th improvement-technology package is sufficient. This is in line with the results of the initial soil analysis which showed that the P content in the soil was classified as high (Table 1). The availability P in saline soils is often fixed by Al and Fe to become less available to plants [26]. When the plants were 60 DAP there was an increase in P content, which was 0.39-0.45% (Figure 2). The limits of adequacy P nutrient levels by soybean plants before flowering period ranged from 0.30 to 0.50% [24]. Thus, the nutrient content of soybean plants at the age of 40 DAP and 60 DAP are in the
The function of P for plants serves to stimulate root growth, especially at the beginning of growth, accelerate flowering, and important for pods filling.

![Figure 1](image1.png)

**Figure 1.** Leaf N content at 40 and 60 days after planting.

As well as N and P content in the leaf, K content in the leaf at 40 DAP is lower than at 60 DAP. The leaf K content at 40 DAP and 60 DAP are ranged between 2.77-6.69% and 2.91-8.27% respectively (Figure 3). Adequacy limit of K nutrient content at upper fully developed leaf sampled prior to initial flowering is 1.91-2.50% [24]. Rhizobium inoculation significantly improved the uptake of all other macronutrients (N, K, P, and Mg) and micronutrients (Fe, Cu, Zn, Mn) in soybean shoots over un-inoculated soybean [25]. However, Rhizobium inoculation and P and K fertilization at lower rates are recommended for improved uptake of macronutrients and micronutrients in soybean.

### 3.3. Plant Growth and Seeds Yield

In the 45 DAP soybean plants, application of recommendation technology package produces higher plants compared to farmer’s technology packages. Improvement of recommendation technology by increasing doses of manure, using of rhizobium and mycorrhiza (improvement technology 1-3) does not increase plant height compared to the recommendation package. At the harvest time, except for the improving technology package-4 technology that was able to produce plant height higher than the existing technology (Table 4). This is because the soils in Sidomulyo is very acidic (pH 4.30) and the technology package only uses the leaf fertilizers of gandasil D and B without using dolomite to improve pH and soil nutrient availability (Table 1 and 2). The recommended technology package and improvement technology package 1-4 that is using dolomite increases soil pH from 4.30 (without dolomite) to 5.3 and improvement technology packages 1-4 increase soil pH from 4.30 (without dolomite) to 5.3.
dolomite) to more than 6.0. Addition of NPK and organic fertilizers increases soil nutrient availability (Table 3), so that it improves plant growth as reflected by the increasing of plant height. Plant height on the recommended technology package, at harvest time does not differ compared plant height of farmer’s technology package. The improvement-1 technological package produce plants height higher than farmer’s technology, although not different from the recommended technology package. The improvement-4 technological package, consistently produces the highest plants both when the plants are 45 days old and at the time of harvest (Table 4).

![Figure 3. Leaf K content at 40 and 60 days after planting.](image)

**Table 4.** Plant height at 45 DAP and at harvesting in the several technological packages on tidal swamps.

| Technological package | Plant height (cm) | At harvesting |
|-----------------------|------------------|--------------|
| Farmers               | 38.82 c          | 50.80 c      |
| Recommendation        | 57.97 b          | 68.65 bc     |
| Improvement-1         | 62.02 b          | 76.25 ab     |
| Improvement-2         | 63.70 ab         | 75.85 ab     |
| Improvement-3         | 64.32 ab         | 70.45 abc    |
| Improvement-4         | 74.77 a          | 82.10 a      |

Remarks: Mean values within a column followed by the same letters are not significantly different at p <0.05 according to Duncan’s Multiple Range Test. DAP: days after planting

The leaf chlorophyll index, which is an important indicator for photosynthesis, increased with increasing plant age in all treatments beginning from 45 DAP to 65 DAP. This is accordance with the nature of soybean growth which indicates that the maximum leaf chlorophyll content occurs in the growth period of R4-R6, which is the period of fast pod filling period (R5). In contrast to the development of plant height, leaf chlorophyll index between treatments at age of 45 and 65 DAP was not different (Table 5). This is due to the maximum chlorophyll content in the leaves, so that the additional fertilizer input does not affect the increase of leaf chlorophyll index. The number of root nodules per plant beginning from 45 DAP still increased until the plant was 65 DAP. At the age of 45 DAP the number of root nodules increased with the improvement technology from farmer’s technology (13.25 nodules per plant) to recommendations technology package which produced 32.13 nodules per plant. This has an impact on improving plant growth as indicated by the increase of plants weight at the age of 45 DAP (Table 5). The number of root nodules increases more especially at the age of 65 DAP with the using of Rhizobium inoculant “Agrisoy” (technological package 1-4) compared to the recommendation package that does not use Rhizobium. At the age of 65 DAP, soybean root nodules have begun to decay as the plants grow older before the harvest. The increasing number of root nodules due to the addition of Rhizobium inoculants is due to the land used in the research rarely has not been planted soybeans, so that the population of Rhizobium bacteria in the soil is low. Inoculation of Acid-
Al tolerant of B. japonicum strains on acidic soils could increase soybean plant height, shoot and root weight, number of flowers, pods, seeds, seeds dry weight, and shoot and seed nitrogen content [27]. At harvest time, the number of filled pods per plant increases with the improvement of the farmer’s technology package to become a technology recommendation. The number of pods increase with the introduction of improvement technology packages 1 to 4 although not significant (Table 6). The weight of 100 seeds also increased with the improvement of farmer’s technology by applying of recomendation technology and improvement technology packages. In line with the number of pods per plant and 100 seeds weight of farmer’s technology package which is lower than recommendation technology or improvement technology, the yield of soybean increased significantly (86%) with the implementation of recommendation technology from 1.00 t/ha to 1.86 t/ha. These results are still increasing to 2.00 t/ha (100%) with using of the improvement technological package 1. However, additional inputs in the form of dolomite, N and P fertilizers were not able to increases seeds yield as compared to the recommendation technology and improvements technology-1 (Table 6).

Table 5. Chlorophyll indexs of soybean leaves in several technological packages on tidal swamps.

| Technological package | Indexs of chlorophyll 45 DAP | Indexs of chlorophyll 65 DAP | Number of root nodules 45 DAP | Number of root nodules 65 DAP | Stem dry weight 45 DAP (g/plant) | Stem dry weight 65 DAP (g/plant) |
|-----------------------|-----------------------------|-----------------------------|-------------------------------|-------------------------------|--------------------------------|---------------------------------|
| Farmers               | 37.00 a                     | 39.67 a                     | 13.25 c                       | 27.29 b                       | 2.84 d                         | 5.12 c                          |
| Recomendation         | 37.40 a                     | 41.47 a                     | 32.13 b                       | 48.79 a                       | 4.16 c                         | 5.12 c                          |
| Improvement-1         | 36.95 a                     | 43.52 a                     | 31.29 b                       | 53.70 a                       | 4.52 c                         | 5.12 c                          |
| Improvement-2         | 38.27 a                     | 42.25 a                     | 30.29 b                       | 65.50 a                       | 4.53 c                         | 5.12 c                          |
| Improvement-3         | 37.57 a                     | 42.22 a                     | 34.63 ab                      | 47.95 a                       | 5.14 b                         | 5.12 c                          |
| Improvement-4         | 38.32 a                     | 40.82 a                     | 41.38 a                       | 55.04 a                       | 5.88 a                         | 5.12 c                          |

Remarks: Mean values within a column followed by the same letters are not significantly different at p <0.05 according to Duncan’s Multiple Range Test.

Table 6. Pods filling and 100 seeds weight soybean seeds at harvest in technological packages on tidal swamps.

| Technological package | Number of filled pods/plant | 100 seeds weight (g) | Seeds yield (t/ha) |
|-----------------------|-----------------------------|----------------------|-------------------|
| Farmers               | 35.55 c                     | 14.21 b              | 1.00 b            |
| Recomendation         | 42.50 abc                   | 16.56 a              | 1.87 a            |
| Improvement-1         | 43.90 abc                   | 16.30 a              | 2.00 a            |
| Improvement-2         | 47.55 ab                     | 16.65 a              | 2.00 a            |
| Improvement-3         | 40.00 bc                     | 15.98 a              | 2.02 a            |
| Improvement-4         | 52.92 a                     | 16.37 a              | 1.95 a            |

Remarks: Mean values within a column followed by the same letters are not significantly different at p <0.05 according to Duncan’s Multiple Range Test.

4. Conclusion

Plantation of oil palm on type C of tidal swamps is suitable for soybean developing. On the tidal swamps with pH soils 4.30, low of K and Ca, recommendation technology package could increase seeds yield 86% from farmer’s technology 1.00 to 1.86 t/ha. Improvement-1 technology packages could increase seeds yield 100% from farmer’s technology 1.00 to 2.00 t/ha. Increased doses of dolomite, organic fertilizer, N, and P fertilizers from improvement-1 to improvement-4 technology package did not significantly increase seeds yield. This finding suggest that for developing soybean on tidal swamps, recommendation technology or improvement-1 technological packages could be recommended.

References
[1] Suwandi, Syamsuri P, Candradijaya A and Sulaksono A 2014 *Pertanian bio industri berkelanjutan, Solusi pembangunan pertanian Indonesia masa depan* (Jakarta, Indonesia)
[2] Kementerian Pertanian 2018 *Data produksi dan luas panen kedelai tahun 2014-2018* (Jakarta: Kemenpan) available at http://www.pertanian.go.id/home/?show=page&act=view&id=61
[3] Statistics Indonesia 2019 *Luas panen dan produktivitas kedelai tahun 2015 di Indonesia* (Jakarta:...
BPS) Available at https://www.bps.go.id/dynamictable/2015/09/09/870/luas-panen-kedelai-menurut-provinsi-ha-1993-2015.html

[4] Nainggolani K and Rachmat M 2014 Pangan 23 83-93
[5] Aldillah R 2015 Jurnal Ekonomi Kuantitatif Terapan 8 9-15
[6] Harsono A 2016 Langkah merengkuk swasembada kedelai, Ragam pemikiran pengembangan pertanian 2015-2016 (Jakarta: Forum komunikasi profesor riset)

[7] Ritung S, Suryani E, Subardja D, Sukarman, Niroho K, Suparto, Hikmatullah, Mulyani A, Tafakresnanto C, Sulaeman Y, Subandiono RE, Wabyunto, Ponidi, Prasodjio N, Suryana U, Hidayat H, Priyono A and Supriatna W 2015 Sumberdaya lahan pertanian Indonesia: Luas, penyebaran, dan potensi ketersediaan Jakarta, Indonesia (Jakarta: Kemenpan)
[8] Mulyani A, Nursamsi D and Harnowo D 2017 Potensi dan tantangan pemanfaatan lahan suboptimal untuk tanaman aneka kacang dan umbi (Malang, Balitkabi) p16-30
[9] Gunawan I 2013 Luas kebun sawit mencapai 13,5 juta hektar (Jakarta: Bisnis) Retrieved from https://bisnis.tempo.co/read/534988/luas-kebun-sawit-mencapai 135 juta hektare/full&view=ok
[10] Wijanarko A and Taufiq A 2016 Agrivita Journal of Agricultural Science 38 14
[11] Pujiwati H, Ghulamahdi M, Yahya S, Aziz S A and Haridjaja O 2016 Jurnal Agronomi Indonesia 44 248-55
[12] Yu H N, Liu P, Wang Z Y, Chen W R and Xu G D 2011 Crop Protect. 30 323
[13] Pujiwati H, Ghulamahdi M, Yahya S, Aziz S A and Haridjaja O 2015 Agrivita Journal of Agricultural Science 37 0126
[14] Stein R J, Duarte G L, Spohr M G, Lopes SIG and Fett J P 2009 Ann. Appl. Biol. 154 269-73
[15] Ghulamahdi M, Melati M and Sagala D 2009 Jurnal Agronomi Indonesia 37 226-34
[16] Taufiq A, Marwoto, Rozi F and Mejaya I M J 2009 Peningkatan produksi kedelai di lahan pasang surut (Malang, Balitkabi)
[17] Marwoto, Taufiq A and Suyamto 2012 Jurnal Lithang Pertanian 31 169
[18] Wardhana S, Mawarni L and Barus A 2014 Jurnal Online Agroteknologi 2 1037
[19] Heriyoanto and Rozi F 2011 Pengembangan kedelai di lahan pasang surut type C di Kalimantan Selatan: Studi dengan pendekatan TOWS dan daya saing komoditas (Malang, Balitkabi) p 402-411
[20] Subandi, Marwoto, Adisarwanto T, Sudaryono, Kasno A and Hardaningih S 2007 Panduan umum pengelolaan tanaman terpadu kedelai (Malang, Balitkabi)
[21] Sumarno and Mansyuri A G 2013 Persyaratan tumbuh dan wilayah produksi kedelai di Indonesia (Bogor, West Java, Indonesia) p 75-103
[22] Lubis D S, Asmarlaili S H and Sembiring M 2015 Jurnal Online Agroekoteknologi 3 11-19
[23] Wijanarko A and Purwanto BH 2017 J. Degraded Min. Land Manag. 4 837-43
[24] Vitosch M L, Johnson J W and Mengel D B 1995 Tri-state fertilizer recommendations for corn, soybeans, wheat, and alfalfa (Michigan, USA)
[25] Nyoki D and Ndakidemi P A 2018 Rhizosphere 5 51
[26] Ch'ng H Y, Ahmed O H and Majid N M A 2014 Sci. World J. 1
[27] Situmorang ARF, Mubarak N R and Triadiati 2009 Hayati Journal of Biosciences 16 157