Amelioration effect of rice productivity on newly opened paddy field in West Kalimantan

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Abstract. The expansion of rice fields in West Kalimantan through the open of new paddy fields has been carried out in several districts and the area has reached 11,296 hectares of the 2016 target of 19,000 hectares. Efforts to expand new open fields for paddy farming, especially in acid sulphate (tidal) land, will still face a number of problems, therefore the application of location-specific technologies based on land conditions and characteristics is very important to note. Efforts need to be made for rice farming in new open fields with drainage water management and washing in paddy fields to reduce the concentration of Fe$^{2+}$ solubility and other toxic elements, nutrient management with balanced fertilization and the application of ameliorant materials. The aim of this study is to find out the productivity of new open field rice by providing ameliorant material. The methodology used in this study was a randomized block design with the treatment of four treatments namely biochar, manure, and lime each repeated six times. The results of the study showed that the application of biochar gave the highest yield of 5.76 t ha$^{-1}$ and was different when compared to other treatments.

1. Introduction
The Indonesian government seeks to realize food sovereignty, by targeting sustainable food self-sufficiency in strategic commodities such as rice. In the last 5 years, the current level of rice and soybean production in Indonesia has risen. Rice production in 2017 reached 81,382 million tons of milled dry grain (GKG) equivalent to 47,332 million tons of rice, an increase of 2,027 million tons (2.56\%) from rice production in 2016 which amounted to 79.355 million tons of GKG. Meanwhile, Indonesia's population in 2017 was 262 million and the average rice consumption rate is 114.6 kg / capita / year. In 2016, Indonesia's rice surplus reached 11.4 million tons. Meanwhile, rice production in West Kalimantan has increased by 10.04\%, amounting to 137,028 tons from 1,364,524 tons in 2016 to 1,501,552 tons in 2017 [1].

National food needs, especially rice each year will continue to increase along with the increase in population and reduced fertile land for agricultural is a problem and a serious challenge for agricultural development in Indonesia. The results of expert research estimate that Indonesia will experience a rice deficit of 9,668 million tons in 2020, meanwhile, to meet the increased demand for rice, according to experts, an additional area of 20,250 hectares of rice is needed per year [2]. One alternative solution to the problem and at the same time answering the challenge was utilizing tidal
swamp land as an expansion of agricultural production areas, especially rice plants, considering that the area is very large while its utilization has not been carried out intensively. Therefore, it is very necessary for rice cultivation technology that can increase rice productivity in new open fields in tidal swamps.

Table 1. Area of New Opened Rice Fields of West Kalimantan Province

| No. | Regency    | Area (Ha) |
|-----|------------|-----------|
| 1.  | Sambas     | 1,490.00  |
| 2.  | Kubu Raya  | 2,000.00  |
| 3.  | Bengkayang | 1,000.13  |
| 4.  | Landak     | 5,222.07  |
| 5.  | Sanggau    | 6,840.02  |
| 6.  | Sekadau    | 852.53    |
| 7.  | Melawi     | 465.57    |
| 8.  | Sintang    | 2,315.00  |
| 9.  | Kapuas Hulu| 1,799.10  |
| 10. | Ketapang   | 1,400.00  |

Total: 23,384.42

Source: [3]

The expansion of rice fields in West Kalimantan through the opening of new paddy fields has been carried out in several districts and the area has reached 11,296 hectares (59%) of the 2016 target of 19,000 hectares [4]. Whereas in 2017 new paddy field opened data has reached 23,384 ha (Table 1). However, the expansion of the new openings is still experiencing problems and problems, especially the productivity of land that is still low because the concentration of toxic elements such as Fe, Al, Mn and deficiency of nutrients P, K, Ca, Mg, Zn and soil pH is relatively low [5].

Efforts to expand new open fields for paddy farming, especially in tidal land, will still face a number of problems, therefore the application of location-specific technologies based on land conditions and characteristics is a very important to consider. Efforts need to be made by giving ameliorant to reduce the concentration of solubility of Fe$^{2+}$ and other toxic elements. Therefore, it is necessary to study application of several ameliorants in new open tidal paddy fields in order to obtain the best ameliorant material which can significantly increase the productivity of newly opened paddy field on tidal swampy.

2. Materials and Methods

The research was conducted in the newly opened paddy fields of tidal swampland in Sungai Daun Village, Selakau Sub-District, Sambas District, West Kalimantan Province in 2018. The study site located at 1° 1’ 11” SL 108° 53’ 96”ES, 21, 0 m, 122°. The typical soil type in this area is a alluvial, derived from clay and silt deposits. this soil classified as Entisols in Soil Taxonomy. It generally dominated by slopes of <8% and altitude between 0 - 200 m above sea level.

2.1 Materials

The effect of ameliorant application on the productivity of tidal rice fields is only done on farmers’ land. Ameliorant materials used include husk charcoal (Biochar), chicken manure, dolomite, urea, TSP and KCl.

2.2 Methods

This experiment took the form of a field study on new tidal swamp openings that were opened / printed in 2016. The study was conducted in the rainy planting season (rendengan) on experimental plots, each plot measuring 10 m x 20 m in a randomized block design repeated 6 time. The treatment
is applied as in Table 2. Variables of rice plants were observed growth parameters in the production factor of Mill Dry Grain (MDG) with water content 14% per hectare.

| Code | Treatment                  | Dosage (t ha⁻¹) |
|------|----------------------------|-----------------|
| T0   | Without ameliorant (control) | 0               |
| T1   | Chicken manure             | 5               |
| T2   | Dolomite                   | 5               |
| T3   | Husk charcoal              | 5               |

The effect of treatment on the observed parameters was carried out by analysis of variance (ANOVA) using the F test at the confidence level of 5%. If the F test shows significant or very significant effect, then to find out whether there are significant differences between treatments, the DMRT (Duncan Multiple Range Test) mid-range test is carried out at the 5% confidence level [6].

3. Result and Discussion

3.1 Field Characteristic

New opening paddy fields in Sungai Daun Village, Selakau Sub-district, Sambas, opened 50 hectares in 2016. In 2017 newly planted rice by farmers under the combined farmer Group (Gapoktan) joint ventures in the village of Sungai Daun, but the results of the paddy are not optimal productivity is still low than 2 t/ha.

![Figure 1](image)

**Figure 1.** New Openings of Tidal Rice Fields at the Study Site of Sungai Daun Village, Selakau Sub District, Sambas District, West Kalimantan Province. a) Existing conditions of new open fields, b) New open paddy fields after processing, c) Rice planting method of jajar legowo 2:1, d) Harvest rice in the fields of new openings

The research begins with a survey of the location of the newly opened rice fields, the rice field is a tidal rice field that experienced tides in the daily water and its fields are flooded in large pairs only.
Soil sampling was done to be analyzed in the laboratory (Table 3). Tidal rice fields of newly opened carried out soil tillage and mudding. Rice planting uses Margasari varieties and is carried out with Legowo 2:1. Rice fertilization based on recommendations at dosage of Urea 200 kg/ha, TSP 100 kg/ha and KCl 100 kg/ha (Figure 1).

The newly opened paddy fields have various problems ranging from physical, chemical and biological constraints, and various social, institutional, and infrastructure constraints. Based on the physicochemical properties of new open field rice fields with very high Fe and Al oxides [7] and in a reduced condition, dissolved oxides can poison plants. Plants will be poisoned Fe if the Fe content in the soil exceeds 2,000 ppm [8], or if the iron content in plants exceeds 300 ppm [9]. The physicochemical properties of new open-field paddy fields at the study site are characterized by the presence of glei soil layers which are grayish in color due to the initial conditions which are always inundated for very long periods of time resulting in reduction of ferric iron to ferrous iron. In this study the condition of the land is flooded in large tides and during the rainy season so that the color of the glei in the grayish soil layer is still visible.

Table 3. The characteristics of Newly opened paddy soil from tidal swampland Sungai Daun Village, Selakau Sub-District, Sambas District, West Kalimantan Province.

| Soil properties          | Value  | Level       |
|-------------------------|--------|-------------|
| pH H₂O 1:2              | 5.92   | slightly Acid |
| pH KCl 1:2              | 5.4    |             |
| C-Org (%)               | 2.20   | Medium      |
| N Total (%)             | 0.26   | Medium      |
| P Bray I (ppm)          | 62.3   | Very high   |
| Extract NH₄OAc 1N pH 7  |        |             |
| K (cmol(+)/kg⁻¹)        | 0.90   | High        |
| Ca (cmol(+)/kg⁻¹)       | 8.94   | Medium      |
| Mg (cmol(+)/kg⁻¹)       | 12.86  | Very high   |
| Na (cmol(+)/kg⁻¹)       | 7.24   | Very high   |
| CEC (cmol(+)/kg⁻¹)      | 32.12  | High        |
| BS (%)                  | 94.28  | Very high   |
| Fe (ppm)                | 1121.14| Very high   |

Texture

| Sand (%)  | 2.70   |
| Silt (%)  | 40.18  |
| Clay (%)  | 57.12  |

Source: [10].

The soil reaction is acidic, amounting to 5.92. Acid pH will cause high in the form of reduced Fe [11]. According to [12], the reduction of Fe³⁺ iron to Fe²⁺ occurs in soaking the soil of the newly opened rice fields. The content of Fe in this land reaches 1,121.14 ppm and was classified as very high. High concentrations of iron in soil solutions that can cause iron poisoning and harm plants. It is marked by slow growth and rust spots on older leaves. The critical limit of Fe poisoning for rice planted in tidal areas is 260 ppm [13].

3.2 Grain Yields

The results of the analysis of variance and further tests showed that the dry grain weight of grain (14% moisture content), respectively T0, T1, T2, and T3 showed a significant difference. The T3 treatment in which the newly opened rice field in tidal land was treated with the application of husk charcoal (biochar) gave the highest yield of 5.76 t ha⁻¹. While the lowest is T0 (control) treatment
which is equal to 2.27 t ha\(^{-1}\). In T1 (chicken manure 5 t ha\(^{-1}\)) and T2 (dolomite 5 t ha\(^{-1}\)) treatment show no significant difference, each of them was 4.32 t ha\(^{-1}\) and 4.30 t ha\(^{-1}\) (Table 4).

**Table 4. Differences of middle value of DMRT of the Dry milled grain yield per hectare (MC 14%)**

| Code | Treatment                  | Dry milled grain yield per hectare (MC 14%) (t ha\(^{-1}\)) |
|------|----------------------------|---------------------------------------------------|
| T0   | Without ameliorant (control) | 2.27a                                             |
| T1   | Chicken manure             | 4.32b                                             |
| T2   | Dolomite                   | 4.30b                                             |
| T3   | Husk charcoal (biochar)    | 5.76c                                             |

Description: The number in the same column followed by the same letter had no significant at 5% level based DMRT.

Giving biochar can increase dry milled grain because biochar improves some soil properties (Figure 2). \[1\] further explained that biochar in the soil can provide a good habitat for soil microbes such as bacteria that help in mineralisation nutrients so that these nutrients can be absorbed by plants. In addition, biochar can also effectively resist loss of nutrients due to washing and retention of P, so that plants can up take P in sufficient quantities to increase growth and yield. The results of the study by \[1\] showed that the addition of biochar from husks was able to increase the average yield of 13.52 tons ha\(^{-1}\) of Sanberasi U3 variety rice in the new open fields of Teureubeh Village, Kota Jantho Sub District, Aceh Besar District.

**Figure 2.** Milled dry rice yield (14% moisture content) from several treatments

### 4. Conclusion

Application of ameliorant in the form of charcoal husk (biochar) on the tidal land of new openings can increase rice productivity by 154\% from 2.27 t/ha of Farmers (control) to 5.76 t/ha with the treatment of Charcoal (biochar). Meanwhile, with the application of chicken manure can increase rice productivity by 90\% and the provision of dolomite can increase rice productivity by 89\%.

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